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# Stock status and indicators for the Bay of Fundy lobster fishery, Lobster Fishing Areas 35, 36 & 38

# État des stocks de homard et indicateurs pour la pêche de homard de la Baie de Fundy, zones de pêche du homard 35, 36 et 38

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## ABSTRACT

In the Bay of Fundy (BOF), lobster (*Homarus americanus*) is a valued resource shared principally by lobster fishers from three lobster management units referred to as Lobster Fishing Areas or LFAs. The Bay of Fundy lobster fisheries (LFA's 35, 36 & 38) are managed by input controls including a common minimum size limit of 82.5 mm carapace length (CL), prohibition on landing V-notch or berried females, limited entry, seasons and trap limits (Table 1). In the three LFA's of the BOF, there are a total of 403 Category A and 7 Category B licenses. The number of participants, and trap limits vary among LFA's. In the present assessment it is the first time indicators have been used to assess the BOF lobster fishery. Abundance indicators for legal size lobster which includes landings and catch rate from at-sea sampling data are primarily positive. Landings in the BOF as a whole continue to be above long-term average and have stabilized at a historical high plateau during the last five seasons. Landings in 2005-06 peaked at an historical high of 3997 t. Landings in each LFA, generally followed the pattern of the BOF as a whole. Fall catch rates, based on sea sampling were generally high, except for the upper BOF, compared to the 1997-2001 period. Fishing pressure indicators based on the 2003-06 sea sampling data and the 2004-05 landings indicates the stock is still fished at moderate levels with estimates for exploitation based on Length Cohort Analysis on the order of between 52 to 58%. No comparison with previous assessment could be made with catch rates (CPUE), due to the fact that the recent grid based logbooks were only introduced during fall 2003. Production indicators showed either no changes or were positive in relation to reference periods. Since 1992, pre-recruit abundance (one-year prior to the fishery) based on fall at-sea sampling for the Bay of Fundy has been high. During the last five years, pre-recruit abundance has been relatively stable as a whole with some decreases at two index ports (Alma and Dipper Harbour and increases at two other index port Seal Cove and Victoria beach). Based on at-sea sampling and dive surveys berried females were in general more abundant from the late 1990s to the present, in comparison to the 1980s and early 1990s. Lobster settlement index (since 1991) based on fall diving surveys off Beaver Harbour (LFA 36), showed an historical high settlement densities pulse of recruitment in 2005 and 2006. These historically high settlement densities were also evident along the north eastern coast of Maine.

## RÉSUMÉ

Dans la Baie de Fundy (BDF) le homard (*Homarus americanus*) est une ressource de grande valeur partagée principalement par des pêcheurs provenant de trois zones d'aménagement appeler Zone de Pêche du Homard (ZPH). La pêche dans la Baie de Fundy est assujettie à des mesures de gestion, soit une longueur de carapace (LC) minimale commune de 82.5 mm, l'interdiction de débarquer des femelles oeuvées ou avec une encoche en V, un accès limité, une saison de pêche et une limite dans le nombre de cassier. Dans les trois ZPH de la BDF, il y a un total de 403 licences de catégorie A et 7 de catégorie B. Le nombre de participant et les limites de cassier varient entre chaque ZPH. Dans la présente évaluation, on utilise pour la première fois des indicateurs afin d'analyser la pêche. Les indicateurs de l'abondance des homards de taille réglementaire, comprenant les débarquements, les taux de prises et les données d'échantillonnage en mer, sont essentiellement positifs. Les débarquements dans la BDF continues d'être au-dessus de la moyenne à long terme et se sont stabilisés à un haut plateau historique pendant les dernières cinq saisons. En 2005-06, les débarquements ont atteint un sommet historique de 3997 t. Les débarquements dans chaque ZPH ont généralement suivis la même tendance que dans l'ensemble de la BDF. Durant l'automne, les taux de prises, basés sur l'échantillonnage en mer étaient généralement plus élevés, avec l'exception de la partie supérieure de la BDF, en comparaison avec la période entre 1997-2001. Les seuls indicateurs de la pression de pêche étaient basés sur les données d'échantillonnage en mer pendant 2003-06 et les débarquements de 2004-05. Ils indiquent que le stock est exploité à un niveau modéré avec un niveau d'exploitation, basé sur une Analyse de Cohorte de Longueur, entre 52 et 58%. Aucune comparaison avec l'évaluation précédente ne pourrait être faite avec les taux de prise (PUE) basés sur les données des journaux de bord, en raison du fait que les récents livres de bord ont été seulement introduit durant l'automne de 2003. Les indicateurs de production étaient soit inchangés, soit positifs par rapport à les périodes de référence. Depuis 1992, l'abondance des prérecrues (une année avant la pêche), basée sur l'échantillonnage en mer durant l'automne, a été élevée. Durant les dernières cinq années, l'abondance des prérecrues a été relativement stable dans l'ensemble, avec une diminution à deux ports index (Alma et Dipper Harbour) et une augmentation à deux autres ports index (Seal Cove et Victoria Beach). Basé sur l'échantillonnage en mer et des relevés de plonger, les femelles ovigères étaient en général plus abondantes à partir des années 1990 jusqu'à présent, comparé avec les années 1980 et au début des années 1990. L'indice de recrutement de homard (depuis 1991), basé sur des données de relevés de plonger en automne à partir du port de Beaver Harbour (ZPH 36), a montré des pics historique élevés dans la densité de recrutement en 2005 et 2006. Ces hauts recrutements historiques étaient aussi évident le long des côtes nord est du Maine.

## 1. INTRODUCTION

In the Bay of Fundy, Canada, the American lobster (*Homarus americanus*) is a valued resource shared principally by lobster fishers from three lobster management units referred to as Lobster Fishing Areas or LFA' s (Fig. 1). The Bay of Fundy fisheries (LFA's 35, 36 & 38) are managed by input controls including a common minimum size limit of 82.5 mm carapace length (CL), prohibition on landing V-notch or berried females, limited entry, seasons and trap limits (Table 1). In the three LFA's of the BOF, there are a total of 403 Category A and 7 Category B licenses. The number of participants, and trap limits vary among LFA's. LFA 37 is a shared area where fishermen from LFA's 36 & 38 are authorized by license condition to fish in. With the present fishing season structure, which includes winter fishing off Grand Manan, lobsters are accessible to trap fisheries in various portions of the Bay of Fundy from Oct 14$^{th}$ to July 31$^{st}$ (Table 1).

In summer 2002, a lobster fishery was opened to Canadian fishermen in a disputed area being fished by American fishermen called the Grey Zone or LFA 38B (Fig. 1). The Grey Zone, which is part of LFA 38 lobster fishing grounds during the regular fishing season, is fished by American fishermen throughout the year including the summer months when the Canadian fishing season was closed. The LFA 38B fishery is limited to a maximum of 20, LFA 38 licensed fishermen. The season is open from July to October. An arbitrary quota of 175 t and a 300 trap limit was set.

During the early part of the Bay of Fundy fishery, management regimes evolved independently in each management unit (Lawton et al. 1999). As a consequence of improvement in technology, such as hydraulic haulers, bigger and faster boats, Loran C and eventually GPS, and changes in the way that lobster fishing was conducted, in 1986, outer boundary lines were established between LFA's (Fig. 1). Presently, evidence based on information from the grid based logbook introduced in 2003, indicate that an important component of the Bay of Fundy lobster fleet have expanded their fishing effort to deeper water further from shore and from their home port, thereby exploiting most of the available lobster grounds.

Shared boundaries between LFA's 35-36, 36-38, 35-34, 34-38 and 38-U.S. fishing grounds cover considerable distances due to the coastal physiography of the Bay of Fundy. This has resulted in contention over proposed changes in the management system of component LFA's, as well as concern over the impacts of changes in the management regime in Maine coastal waters. While historically the fisheries were restricted close to shore, fishing grounds have expanded to deeper water. An important component of fishers from LFA 38 have been fishing in deeper waters (down to ~200 m depths) over the winter months at the entrance to the Bay of Fundy since the late 1970's, and in the southern end of LFA 38 since the late 1980's, targeting the migratory movements of mature lobsters. In addition, an extension of fishing grounds in the middle of the Bay of Fundy, along the mid bay boundary between LFA's 35 and 36, has occurred.

This report has the following objectives:

- Evaluate the status of lobster stocks in the Bay of Fundy (LFA's 35, 36, and 38) during 2005-06.
- Evaluate and recommend indicators for monitoring the future health of lobster stock in the BOF, including:

- Abundance indicators such as fisheries legal sizes and pre-recruits.
- Fishing pressure indicators such as effort in trap hauls and effort distribution.
- Production indicators such as recruitment index, berried females.

### 1.1 Biology

The American lobster habitat extends along the Atlantic coast from North Carolina to Labrador. In Canadian waters, lobsters may be fished in deep waters (e.g., Georges Bank, Bay of Fundy (BOF)) but are generally fished close to shore in depths ranging from 1 to 30 m as in the southern Gulf of St Lawrence.

The life history of the lobster can be divided into a benthic and planktonic phase. The planktonic phase follows the hatching of the eggs in July and August. The larvae will go through the free-swimming period that lasts from 3 to 10 weeks depending on environmental conditions, mostly temperature. The planktonic phase ends at stage IV when the larvae settle on the substrate. In the BOF most lobsters mature between 95 and 109 mm CL (8 to 10 years old). Male lobsters become sexually mature at smaller sizes and ages than females. Mating occurs between July and September. Generally, female lobsters extrude eggs one year after mating and carry the eggs, attached under the abdomen, for nearly another year before hatching during the following summer. For the first few years lobsters remain cryptic in or near their shelter to avoid predation.

Mature lobsters seasonally migrate to shallower waters in summer and deeper waters in winter. Over most of the lobsters' range these movements amount to a few kilometers. However, in the BOF, Gulf of Maine, the offshore regions of the Scotian Shelf and off New England, lobsters can undertake long distance migrations of 10s to 100s of kilometers (Campbell 1986; Campbell & Stasko 1985; 1986; Robichaud & Lawton 1991).

Current thinking is that the Bay of Fundy lobsters are considered as one population and as part of the larger Gulf of Maine lobster population which is viewed as a stock complex, which means that there are a number of sub-populations linked in various ways by movements of larvae and adults (Pezzack et al. 2006). The number and distribution of these subpopulations remains unknown.

### 1.2 Recent Management Issues

A major conservation management program was initiated in Atlantic Canada in light of the October 1995 review of the Atlantic lobster fishery by the Fisheries Resource Conservation Council (FRCC, 1995). In their report, the FRCC concluded that under the current management regimes, lobster fishermen generally were "taking too much, and leaving too little". Based on the scientific data available to the Council, they concluded that Atlantic lobster fisheries had high exploitation rate and harvested primarily immature animals, resulting in very low levels of eggs-per-recruit. While they accepted that lobster stocks have traditionally been quite resilient, they concluded that the risk of recruitment failure was unacceptably high and suggested that egg production be increased. A precautionary biological reference point was recommended in the form of a target level of egg production per recruits (E/R) equivalent to 5% of that of an unfished population. After consultation, the Minister decided not to increase egg production to 5% and instead to double eggs-per-recruit in all LFA's.

In the Bay of Fundy, a 4 years management strategy (1998-2001) was developed. As a result the minimum legal size limits were increased (by 1.5 mm CL) and v-notching was introduced (Table 1). The status of the lobster stocks in the Bay of Fundy was last assessed by Lawton et al. (2001b). Because of high recruitment, exploitation rate could not be estimated. The potential benefits in egg production due to v-notching could not be evaluated. In 2002, new data collection and management measures were introduced. A grid based logbook reporting system was introduced during fall 2003. A new management measure introduced in 2003 to return culls (female lobster with only one or no claw) was subsequently removed in LFAs 36 & 38 during fall 2006 because its benefits for egg production could not be evaluated and was perceived to be of little conservation value.

The adjacent LFA 34 fishery was assessed more recently by Pezzack et al (2006). Reference is made to these earlier reports for background information on historical aspects of the fisheries and earlier biological studies. As to assessment methodologies, reference is made to the recent LFA 34 fishery assessment where new assessment methodologies were used based on the grid based logbook reporting system and fisheries indicators (Pezzack et al 2006). The present document updates stock status of LFA's 35, 36, and 38 at the end of the 2005/2006 season. Recent data from biological sampling during the fall 2006 fishery has been included where this helps in interpreting trends; however, no comprehensive analysis is presented on the 2006/07 fishing season.

Potential gains in egg production due to v-notching could not be evaluated because it is a voluntary measure and the actual level of v-notching cannot be accurately determined.

The fishery presently operates on a yearly review basis. The Lobster Conservation Working Group and Scotia-Fundy Region's Lobster Conservation Strategy, recommended that within each LFA, indicators be developed that are supported by a broad representation of stakeholders. The purpose of this Science Advisory Report is to evaluate the 2005-06 stock status of lobster fisheries in the Bay of Fundy, LFAs 35, 36 & 38 and recommend an assessment framework, including indicators for monitoring the health of the lobster stock, to guide future assessments.

## 2. DATA DESCRIPTION

### 2.1 Landings Data

Landings data from 1892 to 1946 are derived from historic records. These data are by calendar year and are summarized by county. Landings from 1947 to 1995 are based on sales slip information from buyers and are summarised by Statistical District (SD) (Fig. 2.1). The mandatory catch reporting system changed in 1995 from a system based on dealer sales slips to one based on individual fishermen sending in monthly catch settlement reports. For all LFA's, the catch settlement report only provided information on daily catch by port and date of landing. Thus, landings data were reported by LFA or SD (Fig. 2.1). In October 2003, a grid based logbook system was implemented in the BOF. These logbook required fishermen to provide information on daily catch and effort by reference to a 10 min x 10 min grid system (Fig. 2.1.1). This provided the first picture of landings and effort distribution in the Bay of Fundy. The Lobster Catch and Settlement Report was implemented in LFA 34 in November 1998.

Lobster landings data from 1989 to 1998 were accessed from Oracle database tables created by DFO's Marine Fisheries Division from data compiled by DFO Statistics Branch into the ZIFF (Zonal Interchange File Format) database. The ZIFF database includes lobster landings by SD, port and date in a series of tables aggregated by year since 1989 (called identified_catches_YYYY). As of 1998, lobster landings were accessed from archived and production components of the MARFIS (Maritime Fishery Information System) database. Data sources prior to 1989 were obtained from Statistics Canada (1892-1976) and the DFO Statistics Branch, Halifax and are summarised in Williamson, (1992). Presently, estimated landings, and all others information pertaining to effort and grid information is obtained from logbook data which are entered into MARFIS. Parallel (more accurate) landings statistics are obtained from sale slip information which is also entered into MARFIS.

### 2.1.1 Grid Landings

Data from the 2003-2006 Lobster Catch and Settlement Reports (LFA's 35, 36 & 38 log books) and landings date from sale slips has been edited to produce two data sets. Set 1 contains only those records with complete effort and location information which are used in calculation of landings by grid and Grid Group catch rate and effort. Set 2 contains all records with a reported catch and is used to calculate total landings for each LFA.

To account for the fact that the Bay of Fundy is divided into three LFAs and is a large and diverse fishing area, indicators were applied either to individual LFAs and to representative ports within each LFA, or to the Bay of Fundy as a whole, based on information extrapolated from smaller units associated to "grid groups" (Fig. 2.1.1). Grids were combined into a total of 7 Grid Groups. Some Grid Groups were based on depth of water to give a near shore and deeper water area perspective. Others were divided based on historical lobster size differences. Indicators were also evaluated based on three fishing periods: Fall – October 15th to December 31st; winter – January 1st to March 31st; and spring – April 1st to July 31st.

## 2.2 At-sea Samples of the Commercial Catch

At-sea samplers collected information from fishermen's catch during normal commercial fishing operations. The data collected included; carapace length measured to the nearest millimetre (from the back of eye socket to the end of the carapace), sex, egg presence and stage, shell hardness, occurrence of culls and v-notches, and number, location and depth of traps. Since 1988 all data are geo-referenced with latitude and longitude.

At-sea sampling provides detailed information on lobster size-structure in the traps (including sub-legal, berried, and soft-shelled lobsters). As all lobsters retained in each trap haul are measured, catch rate data in numbers of lobsters per trap haul (# lob/th) is obtained from at-sea sampling. The numbers caught per trap can also be converted into weight from known length-weight relationships.

Throughout the years, data has been generally obtained through at-sea sampling conducted during the first four weeks of the fall season, and the last 4 weeks of the spring season. Although the timing of sampling has remained relatively consistent, the

number of areas and level of sampling has varied considerably over time (Figs. 2.2.1 & 2.2.2). The number of at-sea samples collected between 1983-84 and 1988-89 varied between 21 and 35 samples annually across the whole BOF (Fig. 2.2.2). Sampling rates dropped between 1989-90 to 1997-98 to between 8 and 19 samples annually as a result of budget constraints. Sampling increased from 1997-98 until 2000-01 to approach sampling rates achieved in the early 1980's (25 to 93 samples). However, since 2001-02, funding for at-sea sampling has been maintained at minimum levels of between 17 and 22 samples per season (Fig. 2.2.2). In the Bay of Fundy, a minimal at-sea sampling program has been maintained in the fall and spring fisheries since 1976. During periods when operating resources were restricted, emphasis was placed on maintaining an annual series at 4 representative ports (Alma, Dipper Harbour, North Head and Seal Cove) (Fig. 2.2.1).

During the last 10 to 15 years there has been an expansion of fishing effort to deeper waters (> 30 ftm) in the middle of the Bay of Fundy between New Brunswick and Nova Scotia and in the southern part of LFA 38 off Grand Manan. Sampling of the deeper water fishery has been sporadic. An exception to this is the deep water (> 50 ftm) fishery off North Head in LFA 38 which has been sampled bi-annually almost every year since 1976.

### 2.3 Scallop Survey

Surveys with scallop drags are conducted annually to assess scallop abundance. These surveys started in the Bay of Fundy in 1981. However, because there were no standard protocol to record the size and numbers of lobster caught as by-catch, only lobster by-catch data since 1997 were used in the analysis. The surveys were conducted between June and September of each year. Lobsters are caught as a by-catch and are measured prior to being returned to the ocean. While the surveys were not designed to assess lobster abundance, it is one of the few fishery independent sources of information on lobster abundance. A description of the surveys can be found in Smith et al. (2003).

### 2.4 Fisheries independent surveys

#### 2.4.1 Time-series on lobster settlement

Air-lift suction sampling of small (0.25 $m^2$) quadrats set in a lobster settlement and nursery areas has been conducted in the Fundy Isles Region of the Bay of Fundy since 1991 (following techniques described by Wahle and Steneck 1991) to document annual lobster settlement patterns. However, from 1996, diving-based studies were reduced in the Bay of Fundy due to funding constraints and emphasis has been on maintaining an annual time series on a lobster settlement index at one study area in LFA 36 (Beaver Harbour; Fig. 2.4.1a).

During 2000, Richard Wahle initiated the "New England Lobster Settlement Index" program. This program included dive sites along the coast of New England from as far south as Rhode Island and as far north as to include the Beaver Harbour study site in the Bay of Fundy (Fig. 2.4.1b).

### 2.4.2 Time-series on lobster spawning area

A study site within Flagg Cove, adjacent to the port of North Head, Grand Manan, in LFA 38 has been revisited yearly since 1989 (Fig. 2.4.2). Transects are deployed perpendicular to the shoreline, the shallowest end placed at approximately below the mean low water mark, extending out 300 meters to a maximum depth of 14-20 m. Divers recorded all lobsters found within 1 m either side of the 300m line (for a total 600 $m^2$ of sea bottom searched). Lobster size (carapace length, CL, mm) and sex, moult stage and egg maturity stage on berried females were recorded on underwater slates. Sampling at Flagg Cove has been conducted annually during September since 1989 and an historical survey was done in 1982.

### 2.4.3 Closed season trapping survey

In 2000, 2001 and 2002, the Grand Manan Fishermen's Association came forward with proposals to conduct closed season trapping surveys in inshore waters off Grand Manan (LFA 38) (Table 2.4.3) (Fig 2.4.3a, b, c & d). With nominal funding by DFO Science for fuel, a lobster fisherman from each of four ports in Grand Manan volunteered 10 fishing days with 50 trap hauls per day.

In addition during August/Sept. 2001, in the upper part of the Bay of Fundy out of season surveys were conducted out of the ports of Alma and Apple River (Table 2.4.3) (Fig. 2.4.3e). Each fisherman agreed to ten hauling days with 50 traps each day. Included in the 50 traps were 20 juvenile experimental traps. In each of the trapping surveys, fishermen recorded the carapace length (CL) and sex of all lobsters in each individual traps along with the location of each traps. The data was subsequently entered by DFO Science in the CRIS data base.

## 3. ABUNDANCE INDICATORS – LEGAL SIZES

### 3.1. Landings

#### 3.1.1. Issues and Uncertainties

Landing levels are a function of abundance, level of fishing effort (trap hauls, soak over days (SOD), timing of effort and fishing strategy), catchability (environmental, gear efficiency, density, and migrations) and the distribution of animals and effort. Changes in any of these can affect landings. Thus landings are not an exact reflection of abundance. Caution must be observed as increasing effective effort or serial depletion of grounds could maintain landings at a high level for a period of time while absolute abundance is declining.

#### 3.1.2. Historic Landings

Commercial lobster fishing began in the mid-1800s and annual lobster landings in the Gulf of Maine were first recorded in 1892. In the Bay of Fundy, landings peaked in 1894 at 1,415 metric tons (t) and were followed by a decline in landings, dropping to 53 t in the early 1900s (Fig. 3.1.2a). Concerns were raised as early as 1872, when a decline in the average size in the catch was first observed in near shore catches. Over the next 50 years, numerous Government Commissions reviewed the decline and recommended

changes in regulations in an attempt to stop further declines. The landings remained low (198-417 t) during the 1920s until the early 1940s. Landings rose following WW II, varying between 438 and 897 t (averaging 666 t) until the mid 1980s. Beginning in 1946-47 landings began to be reported seasonally (Fig. 3.1.2b). From 1946-47, over the next 40 years, landings remained relatively constant averaging 681 t seasonally. One exception was during the 1975-76 when landings dip to 296 t. From 1986-87 to 1993-94, landings stabilized at an average of 998 t (varied between 942 and 1046 t) (Fig.3.1.2b). From 1994-95 landings began to increase as part of a western Atlantic wide pattern that saw landings increased over the entire lobster's range. In the Bay of Fundy, landings peaked at 3997 t during the last fishing season (2005-06) (Table 3.1.2b). During the last five years, the magnitude of landings increases each year have diminished and landings have levelled off at an historical high plateau averaging 3701 t seasonally.

Recent landings (t) have been well above historic means (Fig. 3.1.2c).

| Time Period | Year | Mean (t) | Mean 2001-02 to 2005-06 | Ratio Recent years to long term mean |
|---|---|---|---|---|
| 10 year mean | 1996-97 to 2005-06 | 3100 | 3701 | 1.2 |
| 25 year mean | 1981-82 to 2005-06 | 1831 | 3701 | 2.0 |
| 25 year mean | 1956-57 to 1980-81 | 630 | 3701 | 5.9 |
| 50 year mean | 1956-57 to 2005-06 | 1230 | 3701 | 3.0 |

Other LFAs and regions followed a similar trend in the early part of the century with major declines during the late 1890s to mid 1920s followed by fluctuations through to the 1970s (Pezzack et al. 2006). The increase in landings observed in the BOF during the 1980s was part of a wide scale increase observed over most of the range of lobsters in the western Atlantic. The overall trends were for increased landings during the late 1980s peaking in most areas in the 1990-91 periods. Many areas have since declined including parts of the Southern Gulf of St Lawrence fishery, Quebec, Newfoundland, Atlantic coast of Nova Scotia and Southern New England (Pezzack et al. 2006). In the Gulf of Maine landings have remained high and continue to increase. Landings in Maine and LFA 34 increased rapidly during the 1990s corresponding with similar increases observed in the Bay of Fundy.

In the Bay of Fundy, the proportion of seasonal lobster landings from LFA 38 was higher from 1946-47 until 1994-95 when landings began to increase (Fig. 3.1.2c A & B). Since then, the proportion of landings has been evenly distributed between each LFA. The increase in the proportion of landings in LFAs 35 and 36 can be partly attributed to an increase in fishing effort and the targeting of larger lobsters in the deeper water in the middle of the Bay of Fundy. The increase in catch rates contributed to the activation of dormant licences or semi active lobster fishermen, and subsequently an increase in fishing effort.

### 3.1.3. Statistical Districts Landings

On a sub-LFA scale, landings can be examined by Statistical Districts (SD) (Tables 3.1.3a & b). These landings are based on data from ports of landing or home ports. They do not provide information on where the lobsters are caught but can provide information

on trends in landings within the LFA for the time period prior to the introduction of the grid logbook system during fall of 2003.

Landings by Statistical District reflect the strong landing trend during the mid 1990s across all Bay of Fundy LFAs with the largest absolute increases in the combined SD 38-39 in LFA 35 (Fig. 3.1.3). On a relative scale comparing landings to their 1983-84 levels, the combined SD 38-39 landings increased 20 times up to 2003-2004.

**Indicators Table Summary- Landings**

| Historical Landings – BOF LFAs | LFA 35 | LFA 36 | LFA 38 |
|---|---|---|---|
| Last 5 seasons vs. 10 year mean 1996-97 /2005-06 | + | + | + |
| Last 5 seasons vs. 25 year mean 1981-82 /2005-06 | + | + | + |
| Last 5 seasons vs. 50 year mean 1956-57 /2005-06 | + | + | + |
| | | | |
| Historical landings – Stat Districts (1983-84-present) | | | |
| Last 5 seasons vs. 10 year mean | + | + | + |
| Last 5 seasons vs. 20 year mean | + | + | + |

**Summary**

Landings in LFA's 35, 36 & 38 as a whole continue to be above long-term means. During the last five seasons landings have remain relatively stable at a historical high plateau.

### 3.1.4. Landings by Grid Areas

Landings based on the Grid Groups for fishing seasons 2003-04 to 2005-06 (Table 3.1.4a & b ) are presented by fishing periods (fall, winter, spring) The grid based logbook was only introduced during the fall of 2003 and the reporting of landings by grids was relatively low during the first year especially in LFA 35. The percentage of landings reported by grids increased in LFA's 36 and 38 during the following two seasons. The reporting of landings by grids in LFA 35 has remained relatively low. In addition, landings for the spring period of 2006 are still preliminary and the distribution of landings by grid group does not fully reflect the actual distribution of landings for that time period.

**Percentage of landings recorded by grid number**

| Fishing Season | LFA 35 | LFA 36 | LFA 38 |
|---|---|---|---|
| 2003-04 | 12% | 58% | 68% |
| 2004-05 | 52% | 68% | 78% |
| 2005-06 | 44% | 74% | 79% |

**Summary**

With such a short time series, in combination with the low level of reporting during the first season, determining patterns by grid groups is problematic. No comparison could be

made with the previous assessment (Lawton et al. 2001). No "Indicators Table Summary" of "Landings by Grids" could be produced as in Pezzack et al. (2006).

#### 3.1.5. Discussion

Landings have peeked at an historical high level in 2005-06. During the last five seasons, landings in the Bay of Fundy have remained at historical high levels. Although landings from deeper water from the middle of the Bay of Fundy have increased over the past 10 years landing from the near shore areas have remain high.

Prior to the mid 1970s, in the Bay of Fundy, lobster fishing grounds were mainly limited to depths less than 30 fathoms. During the late 1970s inshore vessels from LFA 38 began exploring further from shore and by the mid 1980s were fishing in deeper water up to 120 ftm along the Grand Manan Channel (Grid Group 5). The LFA 38 fishery continued to expand with some fishermen fishing the deep water all season. In the mid 1990s inshore vessels from LFA 38 expanded their fishing effort in deeper waters off southern Grand Manan (Grid Group 7). In the late 1980s, LFA 35 and 36 fishermen began fishing in deeper waters (> 30-60 ftm) in the middle of the Bay of Fundy in Grid Group 5 and along the mid bay line between LFA 35 and 36. Today an important proportion of the catches come from these areas.

### 3.2. Catch Rate from LFA 35, 36 & 38 Log Books (2003-2006)

Catch rate (CPUE) calculated directly from logbook data for three time periods (fall, winter, spring), by Grid Groups and expressed in kilograms per trap haul (kg/th) are presented in Tables 3.2a & b. In addition, bi-weekly catch rates calculated for each LFA's are presented in Figure 3.2 and Table 3.2c. Catch rates are not corrected for soak time. Soak times are generally shortest during the first weeks of the season and longest during the winter months. Soak times are also generally longer in deeper waters further away from shore.

Due to the short time series (2003-2006), no indicator table of catch rate could be produce for comparison with previous season. In general the catch rates were the highest during the fall at the beginning of the fishing season (Fig. 3.2). In LFAs 35 and 36 the season is closed during the winter. In LFA 38, catch rates were the lowest in March and April. In all three LFAs, landings increased during the last month of the spring fishing season.

### 3.3 Temporal Trends in Catch Rate by Molt Groups from At-sea Sampling

#### 3.3.1. Method

At-sea sampling has been conducted since 1977 at four major ports in the Bay of Fundy (Alma, Dipper Harbour, North Head and Seal Cove) (Fig. 2.2.1). Samples are generally available from the first two weeks of the fall season, and from the last two weeks of the spring season. These periods represent the bulk of each fishing season. Robichaud and Campbell (1991) summarized the initial sea sampling program design, and reported on catch size composition up to the 1988/89 fishing season. In the 2000, Bay of Fundy assessment, Lawton et al. (2001) updated this annual size composition data from the

1990/91 to 1999/2000 fishing season. In this assessment we have updated this time series up to the 2005-06 fishing season (Fig. 3.3a, b, c, & d).

The size groupings (as determined by mean growth rates) are expressed in number of lobsters per trap haul (#lob/th). Molt group 1 (81-83 to 94 mm CL) represents lobsters that moulted into the catchable size in the summer prior to the fall fishing season. Molt group 2 (95-109 mm CL) represents lobsters that have survived one complete fishing season prior to capture in the current season. Molt group 3 (110 + mm CL) contains a broad range of sizes of lobsters that have survived a number of fishing seasons prior to capture.

In the BOF, between fall 1998 and fall 2000, the minimum size limit was increased from 81 to 82.5 mm CL (Table 1C). Therefore, after fall 1998, only lobsters larger than 81 or 82 mm CL were included in molt group 1, depending on when and in which LFA the size increment was implemented.

### 3.3.2. Results and Discussion

Based on fishery sampling in the 1980's and on the 2000 Bay of Fundy assessment, Robichaud and Campbell (1991), and Lawton et al. (2001b) characterized the size composition of lobsters by several specific areas of the Bay of Fundy. They concluded that two fisheries (upper bay fishery in Chignecto Bay, Minas Basin and their approaches and the deep-water fishery at the entrance to the Bay of Fundy) relied principally on intercepting seasonal migrations of larger, mature lobsters, rather than capitalizing on local annual production of new recruits.

In the time series presented in this assessment there is a marked shift in the size composition of lobsters from Alma (upper bay in LFA 35) which signal the appearance and passing of a major recruitment event between 1992 and 1999 (Fig. 3.3e). The catch rate of lobsters in the first molt group (81-94 mm CL) peeked at 7.3 lob/th during fall 1995. Since 1999, the catch rate of lobsters in molt group 1 has fluctuated between 1.0 and 2.9 lob/th. Recent catch rates are higher than during the years prior to fall 1987 and similar to catch rate between fall 1987 and 1991, the period prior to the large recruitment event that occurred between 1992 and 1999. The increase in the first molt group abundance is seen in the spring season samples starting in 1994.

Off Alma, the large pulse of recruitment that occurred in molt group 1 was not as obvious in molt group 2 (Figs. 3.3a & e). Prior to 1989, the catch rate of lobsters in molt group 2 (95-109 mm CL) was below 1 lob/th. After 1989, the catch rates generally fluctuated above 1 lob/th with peaks of 1.9 lob/th in 1993, and 1.8 lob/th in 2001, and lows of 0.3 and 0.6 lob/th in 2004 and 2005 respectively. In 2006 the catch rate was 0.9 lob/th. The catch rate of lobsters in the second molt group during spring remained low (between 0.4 and 0.7 lob/th) with no apparent trend.

During fall and spring, the catch rate of large lobsters in molt group 3 (110 + mm CL) has remained low (generally below 0.5 lob/th) and no trend is apparent (Fig. 3.3e). However during the fall sampling, peek catch rate of 0.7 lob/th was reached during fall 1985, 1991 and 2001, along with an historical record low of 0.1 lob/th in fall 2004.

The Dipper Harbour area is traditionally associated with a recruit-based fishery. During fall, the catch rate of lobsters in molt group 1 has remained above 2 lob/th since 1993,

peeking at 4.1 and 4.6 lob/th in 2003 and 2006, respectively (Fig. 3.3b &e). One exception was in fall 2004 when the catch rate declined to a historical low of 1.4 lob/th. An increase in molt group 1 abundance is seen in the spring season samples starting in 1997. Since 1997, the catch rate of lobsters in molt group 1 has remained between 1.0 and 2.9 lob/th with the exception of 2004 when catch rate dip to 0.7 lob/th.

Traditionally, during fall and spring, catch rates of lobster in molt group 2 (95-109 mm CL) have been low (below 0.6 lob/th) (Fig. 3.3b &e). However, during three of the last four years, the fall catch rates have fluctuated at record highs of between 0.8 and 1.4 lob/th. During spring, peak catch rates of 0.8 lob/th was reached in 1999 and 2005.

Off Dipper Harbour, few large lobsters > 109 mm CL, in molt group 3 are captured. The catch rates of molt group 3 lobsters are typically below 0.2 lob/th. However during fall 2003 and 2004 historical record high catch rates of 0.5 and 0.6 lobsters/ th, were reached (Fig. 3.3e).

The fishery off North Head has traditionally relied principally on intercepting seasonal migrations of larger, mature lobsters, in deep water at the mouth of the Bay of Fundy. Few lobsters from molt group 1 are captured on these fishing grounds (Fig 3.3 c & e). Between 1976 and 1996, the catch rates of lobsters in molt group 1 have fluctuated between 0 and 0.1 lob/th. Since 1996, the catch rates have fluctuated between 0.1 and 0.2 lob/th with the exception of fall 2002 when the catch rate of lobsters in molt group 1 reached 0.6 lob/th.

The catch rate of lobsters in molt group 2 is higher than in molt group 1.Catch rates remained bellow 0.5 lob/th until fall 1999. Since then, the catch rates have fluctuated at record highs of between 0.5 and 0.9 lob/th. Off North Head, most of the catch comes from molt group 3 (110 + mm CL). During fall, between 1976 and 1998, catch rates in molt group 3 fluctuated between 0.3 and 1.0 lob/th and since 1999, catch rates increased to between 1.0 and 1.8 lob/th.

The lobster fishery off Seal Cove (LFA 38) is a recruitment base fishery. Over 80% of lobsters captured off that port are part of the first molt group into the fishery. Few lobsters in the second and third molt groups are captured (Fig 3.3d & e).

Off Seal Cove, between fall of 1978 and 1988, the catch rates of lobsters in the first molt group (81-94 mm CL) fluctuated between 0.9 and 1.9 lob/th (Fig. 3.3e). Subsequently, with the exception of fall 1992, the catch rates in the first molt group have remained relatively stable at a higher level, ranging between 2.2 and 3.1 lob/th. This level has been maintained after the increase of the minimum legal size of 83 mm CL during 1998, which subsequently decreased the span of the first molt group to 83-94 mm CL. Throughout the years, during the spring sampling in June, the number of lobsters in the first molt group has remained generally low (below 0.7 lob/th) with the exception of spring 1990, 1994 and 1997. However during the last three springs the number of lobsters per trap haul in the first molt group has been the highest in the past 30 years, ranging between 1.7 and 2 lob/th (Fig 3.3e).

Caution must be used as trap design and materials have changed during the years and these may affect the catch rates. At sea samples are snap shot pictures of the catch on a single day and location. Location and day within the season vary and may result in the lack of trends in the data. Analysis by individual grids might reduce the variation but the

data set would be greatly reduced and there would be insufficient numbers and years for analysis. A future strategy may be to more intensely sample specific sites.

### 3.4. Scallop Survey

#### 3.4.1. Methods

The scallop survey database was accessed in order to obtain numbers and sizes of lobsters caught as a by-catch during scallop surveys.

#### 3.4.2. Results and Discussion

Locations of scallop tows from 1997 to 2006 are shown for the upper and lower Bay of Fundy in Figure 3.4a. Although, scallop survey information for the Bay of Fundy has been available since 1981, no information on lobster by-catch was recorded until the early 1990's. However from 1990 to 1997 only two lobsters were recorded as by-catch. For this reason only data from 1997 to present was used in the analysis. Also in the lower Bay of Fundy, there were no surveys done during 2004 and 2005 (Fig. 3.4a).

Most lobsters captured are below the minimum legal size (83 mm CL) (MLS), but there are a few large lobsters caught (Fig. 3.4b). The mean number of lobsters per tow for sub-legal and legal sized lobsters in the upper Bay of Fundy was low (ranging between 0 and 0.1 lob/tow) and showed no trends with time (Fig. 3.4c). The catch rates in the lower Bay of Fundy was higher (ranging between 0.5 and 1.8 lob/tow) but nevertheless did not show any trend.

Using lobster by-catch from scallop surveys as an indicator is still problematic. The numbers of lobsters captured per tow was low and the timing and location of the scallop surveys varied throughout the years. However, with a more thorough analysis of the data, taking into consideration only specific location and timing of the survey each year, using lobster by-catch as an indicator could be a useful tool.

## 4. FISHING PRESSURE INDICATORS

### 4.1. Commercial Fishing Effort

#### 4.1.1. Number of Days Fished

**Methods**

Fishing pressure indicators based on Bay of Fundy logbook could not be compared to any reference period due to the recent introduction of these logbooks in fall 2003. However, the number of days fished and the average number of days fished per fishermen were determined using data from the old logbook format for LFAs 35, 36 & 38 dating back to 2002-03. In this set of data, we included all fishing trips where lobsters were caught and sold regardless if the day was a full day of fishing or not.

**Results and Discussion**

The number of days fished per season and the average number of days fished per fishermen during each season is shown in Table 4.1.1. Due to the short time period (2002-06) no comparison could be made. However the data shows that within each LFA the average number of days fished per fishermen was relatively constant between seasons. The average number of days fished per fishermen was the lowest in LFA 36 (range between 41 and 42 days/fishermen) compared to LFA 35 (ranging between 51 and 59 days/fishermen) and LFA 38 (ranging between 51 and 61days/fishermen). The average number of days fished per fishermen was similar between LFA 35 and LFA 38. LFA 36, having the shortest fishing season and the most licence fishermen had the most fishing days ( 5249 to 5858 fishing days) within each season compared to LFAs 35 (4445 to 5202 fishing days) and 38 (4444 to 5507 fishing days) (Table 4.1.1).

The number of days fished during a season can be influenced by weather condition and low catch rate resulting in longer soak days and fewer trips. In this assessment, due to the short time series no indicator summary table could be produced. However, with the introduction of the Bay of Fundy grid based logbooks, using the number of days fished could become a useful indicator of changes in fishing effort.

### 4.1.2. Number of Trap Hauls from BOF Log Book Data

**Methods**

Increases in landings can be related to changes in abundance or changes in effort or catch rate. Prior to the introduction of Bay of Fundy log books in 2003-04 there was no measure of effort other than the number of licenses. With the Bay of Fundy log books it is now possible to determine changes in the number of trap hauls, days fished and changes in areas fished. The data are based on entirely completed records (landings, trap hauls and grid number), and as such does not represent the total effort.

Information on the effective effort was not captured in the Bay of Fundy log books. The effective effort can change with changes in trap design, bait, boat size and fishing strategies (location of trap, soak time, distance between traps on a trawl etc.). Fishermen are continually experimenting with designs and bait to optimize their catch and over time the effectiveness of traps will increase. Our inability to track these changes is an important deficiency in our data.

**Results and Discussion**

Total trap hauls per fishing season and fishing periods by Grid Groups are given in (Table 3.2a & b). Considering the short time series, the low level of reporting in 2003-04 and the incomplete reporting in 2005-06, no indicator summary table could be produce. However, in the future this type of information will be very helpful indicators of changes in the amount and distribution of effort.

## 4.2. Size Composition (% in Molt Group 1)

A simple indicator of changes in exploitation rates are changes in the size frequency of the catch. Though not as precise as other methods it requires less data.

A fishery removes animals in the legal size range. At moderate or high exploitation rates the slower growing larger sizes are reduced and the population size composition is truncated. While an unfished lobster population will contain lobsters larger than 200mm CL, and up to 10 molt groups with a high percentage in the mature age groups (>97mm CL), in the heavily exploited near shore populations the larger sizes are lacking or reduced to very small numbers and catches are dominated by the first molt group, animals that are newly recruited to the legal sizes. These are referred to as recruitment based fisheries.

By measuring changes in the proportion of the catch in the first molt group, one may be able to detect trends in exploitation rates. A weakness of the method is that it assumes constant recruitment. During a period of high recruitment the proportion of the catch in the first molt group will increase. A second weakness is that in fisheries with an already high percentage of the catch in the first molt group, changes may be difficult to detect.

#### 4.2.1. Method

During the last five years, at-sea sampling has been sparse in the Bay of Fundy (Fig. 2.3.1). No sampling was done during the winter period. Reporting of landings by grids only began during the 2003-04 fishing season. Due to the low level of landings reported by grids during the first season (2003-2004) and the incomplete reporting of landings by grid during the last season (2005-06), only the distribution of landings by Grid Groups during the 2004-05 fishing season was used in the analysis. Due to the low level of sampling, and the similarity in size structure between seasons, the size frequency information for the last three seasons 2003-04 to 2005-06 was combined for the analysis.

The catch size frequencies data were available for the fall (Oct-Dec.) and spring time periods (April-July) by Grid Groups. No size frequency data was available in Grid Group 7, and during the winter time period (Jan.-March). Consequently, the size frequency information from Grid Group 6 was used in Grid Group 7, and the size data from the fall period was used for the winter period in all Grid Groups with winter landings. The size frequencies were expanded using landings reported in the LFAs 35, 36 and 38 log books for each Grid Groups and fishing period (fall (Oct.-Dec.), winter (Jan. March) and spring (April-July).

Catch size frequencies for the 2004-05 fishing season were determined for each Grid Group and the proportion of animals in each molt group was calculated. Molt groups for 2004-05 season, were; first molt group (81 or 83-94 mm CL), second molt group (94-109 mm CL), and third molt group (110+mm CL). The size frequency data were combined to give a size frequency for each of the Grid Groups and fishing period. For other Grid Groups, gaps in the data were filled using the size frequency from the previous or following year.

Examples of the size frequencies used are shown in Figure 4.2a with numbers landed at size for the 2004-05 fishing season with the y axis expanded to show the shape of the frequency in those Grid Groups with lower catches.

### 4.2.2. Results and Discussion

The size structure of the catch varied with areas fished and time of year (Figs. 4.2a & b; Table 4.2a, b & c). Grid Groups 6 exhibited typical size frequencies for recruitment-based fisheries dominated by the first molt group (> 84%) and few lobsters > 100mm CL. The upper Bay of Fundy Grid Groups (1, 2, 3 & 4) have a higher percentage of animals in the second molt group (between 25 and 32 %) than Grid Group 6 (14%). In Grid Group 5, which includes the deeper waters of the Bay of Fundy, the catch was dominated by the third molt group (> 110 mm CL) (64%), and the second molt group (30 %) with a wide size range. The proportion of large lobsters in the third molt group is greater than what is observed in the offshore area of LFA 34 (ranging between 44 to 47 %) and in the adjacent offshore (LFA 41) areas.

Establishing an indicator for the changes in percentages of animals in the first molt group over time is not possible in this assessment. However, we were able to compare each Bay of Fundy LFA's for the 2004-05 season with the 1998-99 and 1999-00 seasons which were evaluated during the 2001 assessment (Lawton et al. 2001) (Table 4.2.2d). During the 1998-99 and 1999-00 fishing seasons, 48 and 93 sea samples respectively, were used in the analysis compared to the 17 to 19 sea samples yearly, used in the present analysis (Fig. 2.2.2). In addition, lobsters in the 81 and 82 mm CL size category were included in the first molt group. Also, in the absence of log reporting by grids, the proportions of lobster landed were arbitrarily assign to each Grid Groups.

In the Bay of Fundy as a whole the proportion of lobsters in the first Molt Group (83-94 mm CL) was lower during the 2004-05 season (56%) compared to the 1998-99 (66%) and the1999-00 (65%) seasons (Table 4.2d). The proportion of lobsters in the second Molt Group (95-109 mm CL) was slightly higher at 26% in 2004-05 compared to 23% and 24% in 1998-99 and 1999-00 respectively. However, in the third Molt Group (110 + mm CL) there was a bigger increase in the proportion of large lobsters during the 2004-05 season (18%) compared to the 1998-99 (11%) and 1999-00 (11%) seasons.

The comparison between individual LFA's shows that during the 2004-05 season the proportion of lobsters in the first molt group in each LFA has decreased and that the proportion of larger lobsters in the second third molt group has increased compared to the 1998-99 and 1999-00 seasons (Table 4.2d). This change was the most pronounced in LFA 35, where the proportion of lobsters in the first molt group has decreased by 12 and 13% and the proportion of larger lobsters (110 + mm CL) in the third molt group increased by 9 and 10% (Table 4.2.2d).

It is difficult to determine which processes are having an impact in the different LFA's. Based on the actual number of lobsters landed by molt groups, a decrease in the proportion of animals in the first molt group coupled with an increase in the proportion of large animal in the second and third molt group seams to indicate an increase in the actual number of large lobsters available rather than a decrease in recruitment.

Over the last decade there has been an increase in effort in the deeper water, in the mid-bay area and the targeting of larger size lobsters. Furthermore, the reduction in the proportion of the first molt group can be partly attributed to the targeting of sea sampling to deeper water in the mid bay areas where low numbers of lobsters in the first molt group are present and where at-sea sampling coverage was low or none existing, during the previous assessment (Fig. 2.2.2). During recent years although the number of sea

samples was low, an important portion of the sampling was done in the deeper water in areas in the mid bay. Consequently, the targeting of the sea sampling to deeper water could be impacting on the results.

One of the concerns, in the deep water mid bay areas, is a fishing-down the population of large lobsters, shifting more and more of the landings to the newly recruited animals and reducing the reproductive output. On the other hand by shifting effort towards larger lobsters should reduce fishing pressure near shore and allow larger numbers of smaller size lobsters to reach maturity and reproduce.

Because of the differing potential causes of changes in the proportion in the different size groups, the table below gives the direction of the change rather than whether it is positive or negative for the fishery.

**Indicator Table Summary - Fishing pressure – Molt group percentages**

| | LFA 35 | LFA 36 | LFA 38 | BOF Total |
|---|---|---|---|---|
| % in 1st molt group | -- | -- | -- | -- |
| % in 2nd molt group | + | + | + | + |
| % in 3rd molt group | + | + | + | + |

If there is an actual drop in recruitment or a fishing-down of the larger size lobsters in the midshore areas it would be a concern. Efforts should be directed at assessing this situation and determining if this is what is actually occurring.

### 4.3. Length Composition Analysis (LCA)

An important indicator of the state of a fishery is fishing mortality or exploitation rate. Exploitation rates have traditionally been given for lobster fisheries though the values have at times been questioned. Historically several methods have been used to various degrees. The most common methods are based on size frequencies in the catch, taken from at sea or port samples. Mark recapture, and biomass estimates from trawl surveys have also been used in some areas.

The size frequency methods include, Length Cohort Analysis, the so called Caddy method and more recently the Change in ratio methods. The Mark Recapture methods have had limited use and in the Bay of Fundy where no data is available. Trawl survey data has been used in the USA but no such data is available in the Bay of Fundy. Size data does however exist and the methods based on this have been applied in previous assessments.

Estimation of the exploitation rate of the lobster fishery has been difficult in the past due to lack of sufficient sampling data and knowledge of the catch levels in different areas. Sampling data is still sparse but through the logbooks information on catch by area is available.

The Length Cohort Analysis method has been used in a number of fisheries. The method is reliant on assumptions such as homogeneity of the stock, constant natural mortality (m), growth, recruitment and gear selectivity, equal capture availability, and stock redistribution criteria following capture of part of the stock and no emigration and immigration (Caddy 1975). Results from Length Cohort Analysis must be handled with caution considering that most of the times only few years of data are available.

This method is not following a single cohort over time, but instead assumes that the size frequency represents the abundance of a cohort over time. In practice, however, this is not the case and estimates are generally based on the mean of several years.

In conditions where the recruitment is dramatically changing year to year, the results should be used with caution. Similarly where fishing patterns change, resulting in changes in the mix of sizes in the catch, estimates of exploitation rate will be affected. For example an increase in fishing effort in deeper water areas with a large mean size could result in lower estimate of exploitation rate.

Given these assumptions the reliability of this method has been questioned and in the recent American assessment it was dropped from the methods used. However given the lack of alternative methods available it is suggested that it could be used in this assessment to provide an estimate of the general level of exploitation. When used in the recent LFA 34 assessments it was within the range of two other methods used (Change in Ratio and Gould-Pollock depletion). Even so it is only a rough estimate and cannot be used to track changes in exploitation rates. Improved methods need to be developed, though these will require more and different data.

#### 4.3.1. Method

LCA was developed by Jones (Jones 1974; Jones 1981) based on Pope's (Pope 1972) cohort analysis which assumes that abundance at the end of year 1 can be estimated by the initial abundance(Ni), a half year of natural mortality (M), a mid year catch (C) and natural mortality for the remainder of the year.

$$\left(N_i e^{-0.5M} - C\right) e^{-0.5M} = N_{i+1}$$

Instantaneous mortality (F) can be estimated from a sequence of cohort abundance over several ages. The equation is arranged from oldest to youngest ages.

$$C_i e^{0.5M} + N_{i+1} e^{M} = N_i$$

Many species cannot be aged so an annual model cannot be applied. Jones (1974) modified the equation to include variable time intervals ($\Delta t$).

$$C_i e^{0.5M\Delta t} + N_{i+\Delta t} e^{M\Delta t} = N_i$$

Size distribution of landings was used to estimate the catch for the sequence of time intervals and von Bertalanffy growth parameters were applied to estimate the $\Delta t$. Since, this method is not following a single cohort over time, but instead assumes that the size frequency represents the abundance of a cohort over time, the method assumes constant recruitment. In practice, however, this is not the case and estimates are

generally based on the mean of several years. In conditions where the recruitment is dramatically changing year to year, such values should be used with caution.

The method was further modified by Cadrin and Estrella to include the time of the catch (Tc). This allows it to be varied from 0.5.

$$C_i e^{T_c M\Delta t} + N_{i+\Delta t} e^{M\Delta t} = N_i$$

They also incorporated a quadratic growth curve derived from molt increment and molt probability at-size to calculate $\Delta t$ at-size.

The details of the method, sensitivity analysis and sample outputs are in Appendix 1: Northeast Fisheries Center Reference Document 96-15 (Cadrin & Estrella 1996).

In the present assessments the method of deriving $\Delta t$ was modified. Given that the method is sensitive to growth ($\Delta t$), two models where run, in the first $\Delta t$ was obtained from the output of the Idoine-Rago Egg and Yield per Recruit program as used in the LFA 34 2001 and 2006 assessments (Pezzack et al. 2001; 2006). This program simulates the progression of a cohort through its life time. When the program is run with F=0.0 an output file produces a table of mean number of years at-size which can be used as the $\Delta t$'s. The second size groupings were set at 11 mm, the mean molt increment for females and the $\Delta t$ were estimated based on inter-molt periods and size at maturity data.

Catch at size was estimated by using size frequency data obtain from at-sea sampling and fishery landings data from the Bay of Fundy grid based logbooks during the 2004-05 fishing seasons. The overall catch at size was calculated by extrapolating size from landings by grid groups and time of season (Fall, Winter, Spring). Details of the sampling coverage and the methodology used for the grid groupings are in Sub-section 4.2.1, in the "Size composition" section of this document.

#### 4.3.2. Assumptions and Limitations

Since this method is not following a single cohort over time, but instead assumes that the size frequency represents the abundance of a cohort over time, the method assumes constant recruitment. In practice, however, this is not the case and estimates are generally based on the mean of several years. In conditions where the recruitment is dramatically changing year to year, as has been the case in the Bay of Fundy where recruitment was high in the late 1990s, such values should be used with caution. Similarly where fishing patterns change resulting in changes in the mix of sizes in the catch, estimates of exploitation rate will be effected. For example an increase in fishing effort in deeper water areas with a large mean size coupled with an expansion of the sea sampling in these areas, could result in lower estimate of exploitation rate.

### 4.3.3. Data Input

**Terminal F**

Terminal F is the value of F applied to the last size group. Cadrin and Estrella (1996) showed that the resulting weighted F is not sensitive to this value. Values between 0.1 and 3.0 were applied with no significant effect.

**M (natural Mortality)**

Estimates of M vary but are generally believed to be between 0.1 and 0.15.

**Tc (Time of catch)**

The time of catch is the period in the year when the catch is taken. The year begins in August following the molt and Tc is set as the month in which cumulative landings reach 50% of the total.

**Catch Numbers (Size frequency)**

The methods of collecting size frequencies and weighting the samples to obtain a fishing season size frequency varied by LFA and details should be obtained from the Working Paper for each area. The Southern Gulf of St. Lawrence, LFA 34 -38 used size frequencies weighted by catch to give number landed at-size. The other LFAs used proportion of the catch at-size rather than number. Using landed catch rather than proportions allow estimation of biomass.

The sizes are group into 5mm or 10 mm CL groups. The 10mm groupings are used at larger sizes when numbers in any size group becomes small or are absent. The smaller groupings are most critical at the smaller sizes where $\Delta t$ has the largest changes.

**Delta T**

$\Delta t$ are calculated from the output of the e/r program described by Pezzack et al. (2006) in Part 2 in the LFA 34 CSAS document. The mean time at size for each 1mm size group is obtained from the e/r model output. These are averaged for 5 or 10mm size groups, and then multiplied by 5/11 and 10/11 respectively to correct for the fact that the mean molt increment is 11mm CL. For example:

Mean intermolt of 81-85 mm group is 1.0 years. $\Delta t = 1.0 \times 5/11$ or 0.45

### 4.3.4. Results and Discussion

Over the range of m=0.1 and m=0.15 and using the two estimates of $\Delta t$. the estimate of the exploitation rate falls within the range of 52-58% (Tables 4.3a & b). This is consistent with the size frequencies observed which include many larger mature animals and the lower percentage (56 %) in the first molt group. For comparison in LFA 34 the estimates of exploitation rates were 68% over all and 75% in nearshore areas and the estimates of the percentage in the first molt group was 70-80%.

Using then available size frequency data for the three LFA's, and reported landings, a combined Bay of Fundy LCA was conducted yielding new estimates of exploitation rate in the range of 49-63% over the period 1988 to 1995. (Lawton et al.1999). For the period 1988 to 1993 average exploitation rate for the Bay of Fundy-level analysis was 53%. The LCA analysis was not updated in the 2001 assessment due to the continued indication of high recruitment (Lawton et al. 2001b)

These values are ballpark figures to give an idea of the level of exploitation. There are many of the assumptions that are or could be violated so to present this data as any more then a very rough idea of the levels of exploitation would be wrong. However given the size mix in the fishery and the 56 % in the first molt group, the values of 52-58% seem reasonable.

## 5. PRODUCTION INDICATORS (SETTLEMENT, PRE-RECRUIT AND SPAWNER ABUNDANCE)

### 5.1. Catch Rate of Pre-recruits in At-sea Samples

#### 5.1.1 Methods

In the Bay of Fundy, data on catch rates of pre-recruits to the fishery have been collected during at-sea sampling of the commercial catch. Five representative fishing ports (Alma, Delaps Cove, Victoria Beach, Dipper Harbour and Seal Cove) have been sampled twice during each fishing season for the past 27 years (Fig. 2.2.1). The at-sea sampling was done during the fall at the beginning of the fishing season and during spring or summer at the end of the fishing season. Gaps in the at-sea sampling off Delaps Cove and Victoria Beach occurred in the late 1980s and early 1990s. Other ports like St Martins, Advocate Harbour, North Head and the Wolves have been sampled throughout the years but were not included in the analysis either due to areas of low numbers of pre-recruits or due to sparse sampling. To eliminate some of the bias associated with the size of escape vents throughout the years, only lobsters ranging in size between 75 and 80 mm CL were used in the analysis.

#### 5.1.2. Results and Discussion

The mean catch rate of pre recruits (75-80 mm CL) from at sea samples (1978-2006) are presented in Figure 5.1 for fall and spring fishing periods. Pre-recruit catch rates are highly variable and patterns vary between the fall and spring period. Seal Cove and Dipper Harbour always had larger numbers of pre-recruits (75-80 mm CL than the other ports in the Bay of Fundy (Figs. 5.1). The numbers of pre-recruits in the upper Bay of Fundy (Alma), and along the Nova Scotia shoreline (Delaps Cove and Victoria Beach) was low prior to the 1990s. However, in the early 1990's a large recruitment pulse occurred in the whole Bay of Fundy and was most apparent in the upper Bay of Fundy, off Alma and along the Nova Scotia shore off Delaps Cove and Victoria Beach, in areas where pre-recruit abundance was traditionally low (Figs. 5.1). Unfortunately due to few at-sea samples this trend only became evident off Delaps Cove and Victoria Beach during the mid 1990s.

During the last five years, the number of pre-recruits in the upper Bay of Fundy and along the Nova Scotia shore has stabilized at lower levels still higher than during the pre 1990s levels (Figs. 5.1). However, off Dipper Harbour and Seal Cove the catch rate of

pre-recruits has remained at historical highs both during fall and spring. This is despite the use of escape panels in lobster traps.

Catch rates of pre-recruits is often presented as a tool for tracking recruitment and forecasting future landings. At the present level of sampling, catch rates are highly variable between fall and spring within the same season as well as from year to year. However during the last five years, the catch rate of pre-recruits in the lower Bay of Fundy remained at high levels even reaching historical highs during fall 2005 and spring 2006 off Seal Cove (Figs. 5.1).

In the upper Bay of Fundy and along the Nova Scotia shore the catch rate of pre-recruits has decline. This could be partly attributed to the targeting of larger lobsters in the deeper water in the mid bay area and the shifting of the at-sea sampling to the deeper water areas.

### 5.2. Catch Rate of Berried Females in At-sea Samples

#### 5.2.1 Methods

In the Bay of Fundy, data on catch rates of berried females has been collected during at-sea sampling. Due to low numbers of berried females during the fall period and during the month of June in LFA's 36 and 38, data on berried female catch rate are only shown for the month of July in LFA 35 for four representative ports in the upper Bay of Fundy.

#### 5.2.2 Results and Discussion

The mean catch rate of berried females from at sea samples (1979-2006) are presented in Figures 5.2. Catch rate of berried females can be very variable because of the migratory and congregative nature of mature female lobsters. For these reasons only at-sea samples taken during July in the Upper Bay of Fundy had enough data for the analysis. During the past 27 years, the catch rate of berried females off the port of Alma in July has always been the highest of all the ports sampled (Fig. 5.2). The catch rates between 1979 and 2001 were relatively low (varied between 0.04 and 0.40 berried/th). However, between July 2002 and July 2004 there was a large increase in the catch rate of berried females, reaching as high as 1.4 berried/th in 2003 (Fig. 5.2). This increase was also seen off the other three ports. In 2006 the catch rate of berried females off all ports had returned to historically low level.

As an indicator it appears that berried female catch rates can be of value. However due to its low catch rate level and high variability; increase sampling at the critical time of the year when berried females are migrating into the upper Bay of Fundy is needed.

### 5.3. Fisheries independent surveys

#### 5.3.1. Time-series on lobster settlement

##### 5.3.1.1. Methods

Air-lift suction sampling of small (0.25 m2) quadrats set in a juvenile nursery areas has been conducted in the Beaver Harbour area in LFA 36 since 1991 to document annual lobster settlement patterns (Fig. 2.4.1a). Since 1991, between 2 and 6 specifics sites in

the Beaver Harbour area has been sampled annually in October. At each sampling site a minimum of twelve 0.25 $m^2$ quadrats were sampled in complex cobble-boulder habitats between 5 and 15 meters depth. In this analysis lobsters of less than 13 mm CL are considered lobsters that have settled within the same years as the sampling. The settlement densities are compared to similar cobble-boulder sites along the New England coast (Fig. 2.4.1b). The US data were obtained from R. A. Wahle from the Bigelow Laboratory for Ocean Science, Boothbay Harbour, Maine.

#### 5.3.1.2. Results and Discussion

Since 1991, settlement densities in Beaver Harbour have fluctuated yearly with small peeks during 1992, 1999 and 2003 (Fig. 5.3.1a). The average settlement (<13 mm CL) density between 1991 and 2004 was 0.4 lobster/.25$m^2$. In 2005, the area experience a recruitment pulse (2.0 lobsters/.25$m^2$) equal to a five folds increase above a 13 year average, followed by a higher than average settlement density (1.0 lobster/.25$m^2$) in 2006. Since 2003 settlement densities have been above average (Fig. 5.3.1a).

These settlement densities are comparable or higher to study sites along the New England State (Fig. 5.3.1b). The remarkable feature of the 2005 survey was the pulse of high settlement in north eastern Maine and New Brunswick (Beaver Harbour) (Fig. 5.3.1b). North eastern Maine, which historically has received a relatively poor supply of settlers, saw higher densities that are more comparable to western Maine. Most remarkable were the high numbers in Beaver Harbour, NB, a location that has historically had high numbers. This pulse of settlement in eastern Maine and New Brunswick may bode well for recruitment to the fishery in the future. However the settlement index has not yet been proven to be of predictive value for trends in the abundance of lobsters in the Bay of Fundy and the coast of Maine.

### 5.3.2. Time-series on lobster spawning area use

#### 5.3.2.1. Methods

A lobster spawning area within Flagg Cove, adjacent to the port of North Head, Grand Manan was first determined by diving and trapping in the early 1980's (Campbell 1986, 1990). This site was not resurveyed again until September 1989 when a salmon aquaculture site was in operation (Fig. 5.3.2a). Since 1989, a September dive survey has been conducted annually with the exception of 1994 and 1996 when the survey was done during July or August and during 1990 and 1991 when surveys were done monthly from June to October. In this review, only dive survey data collected during the month of September was used in the analysis.

Diver sampled belt transects (300 m x 2m) along a series of sites within Flagg Cove (Figs. 2.4.2 & 5.3.2). During the period the aquaculture site was in operation (1989-1991) lobster distribution shifted away from locations which had historically been documented as high density sites (Area A & B in Fig. 2.4.2 had higher densities than Areas C). In years subsequent to site removal, the historical pattern of lobster habitat use seen in September was re-established (Lawton at al. 2001). In this analysis only lobsters sampled in Area A & B are used in the analysis (Fig. 5.3.2a).

#### 5.3.2.2. Results and Discussion

Over the period of investigation (1982 to 2006), only data from the September 1990 survey (when cages site were fully operational) is considered bias (Fig 5.3.2b). Berried female densities in Flagg Cove (Area A & B combined) increased gradually from 1993 until 2001 when density of berried females peaked at 4.4 lob/50 $m^2$. Subsequently, density decreased slightly during 2002 and 2003 and in 2004, declined to the same level as in 1995 (1.8 lob/50 $m^2$). However during that same year the density of females with no eggs (1.6 lob/50 $m^2$) and the density of males (1.1 lob/50 $m^2$) were the highest recorded. In 2005, the density of berried females declined to a record low of 0.4 lob/50 m2 (Fig. 5.3.2b). This phenomenal decline in the density of berried females in Flagg Cove happen during the same year as the remarkable increased in settlement density off Beaver Harbour (Fig. 5.3.1a). In 2006, the density of berried females increased four folds to post 1995 levels (1.9 lob/50 $m^2$).

In Flagg Cove, since 1998, we have noted the appearance of smaller lobsters (< 100 mm CL) and sub-legal lobsters (< 83 mm CL) (Fig. 5.3.2b), which were not encountered on this sandy bottom habitat during initial studies in the early 1980's and 1990's (Fig. 5.3.2b). In 2006, the density of lobsters less than 100 mm CL and sub-legal size lobsters peaked at 0.8 and 0.3 lob/50 $m^2$ respectively. Sub-legal lobsters have also been encountered in late 1990's in greater numbers at another soft bottom sampling area in Seal Cove Sound, Grand Manan (Lawton et al. 2001). Such population density and size structure changes at Flagg Cove and Seal Cove Sound during the summer closed season provide corroborative evidence in support of fishery-dependent indices documented by Lawton et al (2001), which indicate a significant recruitment event affected the Bay of Fundy lobster population during the 1990's. During the last five years, this increased in pre-recruit (75-80 mm CL) has also been evident in the at-sea sampling from Seal Cove and Dipper Harbour (Fig. 5.1.2).

### 5.3.3. Closed season trapping survey

#### 5.3.3.1. Methods

The closed season trapping surveys in 2000, 2001 and 2002 off Grand Manan and in the upper Bay of Fundy were designed for various purposes. In the upper Bay of Fundy juvenile traps were used and in northern Grand Manan, smaller inshore traps with escape vents closed were used to determine the distribution of juvenile lobsters. In southern Grand Manan, traps were fished in different locations (near cage sites, or in the Grey Zone, etc,) with different research objectives each year. However, in order to provide decadal-scale comparisons of lobster size frequency in trap catches, and in particular the size composition and relative abundance of berried females only data from commercial traps set in the same general areas as in the historical surveys were used. Although these surveys were designed for various purposes, the locations were selected where data existed from historical studies, or where recent scientific and industry data indicated likelihood of seasonal aggregation of berried females and other mature lobsters (spawning areas), and/or significant abundance of juveniles (nursery areas).

Three general locations were compared; the upper Bay of Fundy (off Alma and Apple River in LFA 35, northern Grand Manan (off North Head in LFA 38) and southern Grand Manan off Ingalls Head, Seal Cove and White Head in LFA 38) (Table 2.4.3). The following molt groups expressed as number of lobsters per trap hauls (lob/th) were

compared; pre-recruits (75-80 mm CL), first molt group (81-94 mm CL), second molt group (95-109 mm CL), third molt group (> 109 mm CL) and berried females.

#### 5.3.3.2. Results and Discussion

These surveys provided information as indicators to assist in the scientific assessment of the Bay of Fundy lobster fishery. During the recent surveys (2000, 2001, 2002) a total of 53,244 lobsters were measured out of 5132 trap hauls (Table 2.4.3). The average catch rate, for all sizes off southern Grand Manan in LFA 38, were extremely high compared to commercial season catch rates, with individual catches up to 40 lobsters and 50 lb. per trap haul. These catch rates are the highest yet encountered in trap sampling projects on lobsters in the Bay of Fundy. Average catch rate for all size groups, over each survey year, varied between 9.9 and 18.2 lobsters per trap haul for southern Grand Manan, between 3.9 and 6.4 lobsters per trap haul for northern Grand Manan, and between 6.1 and 8.3 lobsters per trap haul for the upper bay of Fundy(Table 2.4.3).

Historical data on trap catches of lobsters for equivalent time periods was accessed and made available in a geo-referenced format. Whereas current survey data is resolvable by individual trap (or string) location, historical data is known only from certain broadly-defined study areas (Fig. 2.4.3a). For the northern Grand Manan survey there is a direct spatial overlap between the recent trap locations and historical sampling areas, whereas for southern Grand Manan the historical data is from areas to the southwest, and further offshore than the recent survey which was focussed in inshore areas (Fig. 2.4.3b, c ).

Figure 5.3.3 provides a detailed comparison of historical and current lobster size distribution in the trap catches in terms of number of lobsters per trap haul per size groupings. In relation to the commercial fishery and this lobster stock assessment it is also relevant to consider catch rates in terms of lobster moult groups. Moult groups define size classes of lobster in relation to the range of size increments that typically occur at each moult. Moult groups are also defined relative to the minimum catchable size (Lawton et al 2001; Pezzack et al 2001).

In the upper Bay of Fundy lobster catch rates were much higher in all molt groups during 2001 (overall average between 6.1 and 8.3 lob/th) than during the historical surveys of 1979 and 1980 (overall average between 1.5 and 1.9 lob/th) (Table 2.4.3; Fig. 5.3.3). The only exception was the catch rates of berried females which were lower during the 2001 survey (0.1 and 0.2 berried/th) compared to the 1979 and 1980 surveys (0.4 and 0.5 berried/th). During the historical surveys the number of pre-recruit captured was low (0.04 to 0.1 lob/th) compared to the 2001 surveys (0.3 to 0.7 lob/th).

Off northern Grand Manan the catch rate of lobsters in all molt groups were much higher during the more recent surveys (2000, 2001, 2002) (overall average varied between 3.9 and 6.4 lob/th) in comparison to the historical surveys (1977, 1978 and 1982) (overall average varied between 0.9 and 1.3 lob/th) (Table 2.4.3; Fig. 5.3.3). In addition the catch rate of berried lobsters were much higher during the recent surveys (1.4 to 2.7 berried/th) compared to the historical surveys (0.4 to 0.5 berried/th). During the historical surveys the number of pre-recruits was low (0.01-0.03 lob/th) compared to the more recent surveys (0.11 to 0.19 lob/th).

Off southern Grand Manan, the catch rates of lobsters in all molt groups were also much higher during the more recent surveys (2000, 2001, and 2002) (overall average varied

between 7.0 and 18.2 lob/th) in comparison to the historical survey of 1978 (overall average was 4.5 lob/th) (Table 2.4.3; Fig. 5.3.3). During the recent surveys, the catch rate of berried females off southern Grand Manan (0.2- 0.3 berried/th) remained low compared to northern Grand Manan (1.4-2.7 berried/th), however they were higher than in 1978 (0.1 berried/th). The catch rate of pre-recruits was the highest during the 2000 survey (2.6 lob/th). However, pre-recruits catch rate was lower during 2001 (0.9 lob/th) and 2002 (1.2 lob/th) than during the 1978 survey (1.4 lob/th).

Trapping in southern Grand Manan was dominated by lobsters in the first molt group, which reached approximately 11 lobsters per trap haul during the 2000 survey (Table 2.4.3; Fig. 5.3.3). Catch rates were higher in southern Grand Manan in the first molt group. The catch rates of lobsters in the second molt group were similar to those from the upper Bay of Fundy, and higher to those from northern Grand Manan. However the catch rate of large lobsters (> 109 mm CL) in southern Grand Manan was lower than northern Grand Manan and the upper Bay of Fundy. Interestingly catch rate of larger lobsters during the 2001 survey in northern Grand Manan (1.5 lob/th) was similar to that of the upper Bay of Fundy (1.3- 1.5 lob/th)

Changes in trap types and fishing strategy influence this decadal-scale contrast. However, the generally higher catch rates are consistent with industry observations of higher numbers of lobsters in these inshore areas in recent years. Industry surveys can provide important information on closed season distribution of lobsters and show promise in gaining a better understanding of the relative abundance of large mature lobsters.

## 6. GENERAL DISCUSSION

Indicators for abundance, fishing pressure and production are shown in Table 6.1. They provide a perspective on how different characteristics have changed since the last assessment in 2001.

### 6.1. Abundance Indicators

With the implementation of the Bay of Fundy log books, we will have a powerful set of data. We will have a better grasp of where fishing takes place and how it changes within and between seasons. However, the Bay of Fundy logbooks were only implemented during the fall of 2003. The grid based logbook information was only keyed into new MARFIS tables in November 2005. Consequently, all the grid information from the Bay of Fundy logbooks between fall 2003 and fall 2005 had to be recovered. The landings from these logs are useful as an abundance indicator to the extent that effort remains constant for the periods being compared. Changes in effort may be related simply to more trap hauls, which can be accounted for by calculating catch per unit effort (CPUE). If effort changes in quality, such as changes in fishing strategies, better traps, bait, and navigational equipment, then this can not be captured by most of the indicators we presently have.

It is clear that overall landings and catch rates in the Bay of Fundy were highest in the last 5 years (2002-06) relative to the previous 5 years (1997-2001) and historically (Table 6.1). Most of the indicators of abundance we have are dependent on data from fishing with traps. However, we also have yearly diver base surveys both for berried

females and lobster settlement abundance indicators. We also have available lobster abundance indicators from the Bay of Fundy scallop surveys. These data present a mixed picture, and more years and analysis are needed to evaluate the usefulness of the data collected.

Overall landings are presently at historical highs (2001-02 to 2005-06). Landings are still well above medium (10-yr) and long-term (50-yr) means.

### 6.2. Fishing Pressure Indicators

Due to the short time series (2003-04 to 2004-06) from the logbook data, no long term comparison could be made with previous assessment. However, in the future we will have a more powerful set of data to evaluate fishing pressure.

At this time we don't have long term indicators of exploitation rates. However we were able to compare exploitation rates based on LCA, during the 2004-05 season with that from the 1988-89 to 1993-94 seasons from the 1999 assessment (Lawton et al. 1999). The exploitation rate during the 2004-05 season, ranged between 52 and 58% compared to an average of 53% between 1998 and 1993.

In the present fishery, in the Bay of Fundy, over 56% of lobsters landed are newly recruited animals within the first molt group (83-94mm CL). This proportion of new recruits is lower than during 1998-99 (66%) and 1999-00 (65%). In comparison the proportion of lobsters in the larger molt group (+110 mm CL) has increased to 18% in 2004-05 from 11% during 1998-99 and 1999-00.

### 6.3. Production Indicators

**Pre-recruits**

The catch rate of pre-recruits (75-80 and 77-82 mm CL) from at-sea samples can be of value as an indicator of recruits to the fishery the following season. Pre-recruit catch rates at representative ports, even though they tended to be variable, reflected the large increase in recruitment and landings during the 1990's. If indicators for pre-recruits are to be developed from samples of the commercial catch, sampling rates must increase substantially along with a refinement of the timing when the sampling should be done preferably during the first and last two weeks of the fishing season.

In summary, we have some indicators at key ports in the Bay of Fundy. We also have yearly diver base, fishery independent, juvenile settlement surveys in Beaver Harbour. This diver based time series has provided a lobster settlement density index and will continue to mesh well with existing lobster settlement index projects in the U.S. Gulf of Maine.

**Ovigerous Females**

We have two useful indicators of berried females in the Bay of Fundy. They are found in high enough levels in at-sea samples during July in the upper Bay of Fundy and we have a yearly diver base, fishery independent survey of a berried females spawning area off Flagg Cove, Grand Manan. However, we still need to develop other indicators of abundance for this important component of the lobster population. Out of season trap

samples would increase the chances of getting enough berried females to develop a reliable indicator. We should also examine more closely indicators of females that are mature but not carrying external eggs. A re-examination of size at maturity is also needed.

### 6.4. Overall Stock Status

- Landings in the Bay of Fundy (LFAs 35, 36 & 38) as a whole continue to be above long-term means and during the last five years have stabilized at an historical high plateau. During the 2005-06 season landings peaked at an historical high.
- Fall catch rates, based on at-sea sampling, for the Bay of Fundy were higher except for a decline in the upper BOF (Alma), compared to the 1997 – 2001 period.
- The relationship between increased effective effort and landing trends is a source of uncertainty
- Fishing pressure indicators based on the 2003-06 sea-sampling data and 2004-05 landings, indicates that the stock is still fished at moderate levels with estimates for exploitation based on Length Cohort Analysis on the order of between 52 to 58%.
- There Since 1992, pre-recruit abundance (one-year prior to the fishery) based on fall at-sea sampling for the Bay of Fundy has been high. During the last five years pre-recruit abundance has been relatively stable as a whole with some decreased at two index ports (Alma and Dipper Harbour) and increases at two other index ports (Seal Cove and Victoria Beach).
- Based on at-sea sampling and dive surveys, berried females are generally more abundant from the late 1990s to the present, compared with the 1980s and early 1990s.
- Lobster settlement index (since 1991) based on fall diving surveys off Beaver Harbour (LFA 36), showed an historical high settlement densities pulse of recruitment in 2005 and 2006. These historically high settlement densities were also evident along the north eastern coast of Maine.

### 6.5. Recommendations for Developing Indicators for Monitoring the Future Health of the Lobster Stocks

- Fishery dependent indicators of abundance, such as landings and catch rate, need to be compared with changes in effort.
- Fishery-independent indicators of abundance such as, legal sizes (moult-classes), berried females, and pre-recruits, are needed to overcome the uncertainty associated with fishery-dependent indicators.
- Fishing pressure indicators such as trap-hauls, fishing location, vessel size, navigation, trap design and fishing strategy, are required.
- Production indicators such as newly settled lobster indices should be expanded across the Bay of Fundy in order to improve their predictive value.
- Ecosystem indicators to estimate fishery impacts on the ecosystem with respect to by-catch of non-lobster species and potential impact of lobster fishing on the habitat requires an approach to collect and process new information.
- An assessment framework for the development of indicators related to assessing, stock status, and the effects of management measures need to be developed before the next assessment.

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Table 1. Key management measures presently enforce in the Bay of Fundy.

| Management measures | Description | | |
|---|---|---|---|
| **Lobster Fishing Areas (LFAs)** | **LFA 35** | **LFA 36** | **LFA 38** |
| Fishing season | Oct. 14th to Dec. 31st; April 1st to July 31st | 2nd Tuesday in Nov. to Jan 14th; March 31st to June 30th | 2nd Tuesday in Nov. to June 30th |
| Number of Category A licences (Category B)[1] | 92 (4) | 176 (2) | 135 (1) |
| Number of traps per Category A licence (Category B)[1] | 300 (90) | 300 (90) | 375 (113) |
| One rectangular escape mechanism not more than 250 mm from the floor in the parlor section of trap (dimension in mm)<br>or<br>Two circular openings not more than 250 mm from the floor in the parlor section of trap (diameter in mm) | Dimension of unobstucted opening not less than 44 mm in height and 127 mm in width<br>or<br>Diameter of unobstucted opening not less than 57.2 mm | | |
| Biodegradable mechanism in the parlor section of the trap | Dimension of unobstucted opening not less than 89 mm in height and 152 mm in width | | |
| **Biological measures** | **Description** | | |
| Minimum legal carapace length (mm) | 82.5 | 82.5 | 82.5 |
| Landing of egg-bearing females is prohibited | Common to all LFAs | | |
| Landing of v-notch females is prohibited | Common to all LFAs | | |
| Landing of cull (one claw or no claw) females is prohibited | Only in LFA 35 | N/A | N/A |

[1] Category A represent fishermen with a full set of gear and Category B with lower trap limits

Table 2.4.3. Summary of lobster catches by size groups and berried females in closed season trapping surveys during September and October 2000, 2001 and 2002 off Northern and Southern Grand Manan (LFA 38) and in August and September 2001 in the Upper Bay of Fundy (LFA 35). Also indicated for comparison are the historical out of season surveys in the upper Bay of Fundy during 1979 and 1980, in northern Grand Manan during 1977, 1978 and 1982 and in Southern Grand Manan during 1978.

| Survey Port and Year | 75-80 mm CL No./TH | 81-94 mm CL No./TH | 95-109 mm CL No./TH | >109 mm CL No./TH | Berried | TH | Date |
|---|---|---|---|---|---|---|---|
| Alma 1979 | 0.04 | 0.17 | 0.29 | 0.53 | 0.40 | 2166 | Aug/Sept 1979 |
| Alma 1980 | 0.12 | 0.29 | 0.37 | 0.49 | 0.47 | 1298 | Aug/Sept 1980 |
| Alma 2001 | 0.65 | 1.86 | 1.35 | 1.34 | 0.20 | 325 | Aug /Sept 2001 |
| Apple River 2001 | 0.34 | 3.39 | 2.91 | 1.46 | 0.08 | 315 | Aug. 2001 |
| Northern GM 1977 | 0.03 | 0.04 | 0.08 | 0.78 | 0.37 | 321 | Sept 1977 |
| Northern GM 1978 | 0.01 | 0.04 | 0.08 | 0.54 | 0.42 | 166 | Sept 1978 |
| Northern GM 1982 | 0.01 | 0.07 | 0.15 | 0.43 | 0.43 | 2978 | Sept/Oct 1982 |
| Northern GM 2000 | 0.19 | 1.20 | 0.90 | 1.20 | 0.80 | 493 | Sept/Oct 2000 |
| Northern GM 2001 | 0.15 | 1.09 | 1.22 | 1.50 | 2.41 | 486 | Sept/Oct 2001 |
| Northern GM 2002 | 0.11 | 0.39 | 0.29 | 0.42 | 2.69 | 96 | Sept 2002 |
| Southern GM 1978 | 1.38 | 1.47 | 0.35 | 0.20 | 0.12 | 240 | Sept 1978 |
| Southern GM 2000 | 2.41 | 10.58 | 2.87 | 0.65 | 0.21 | 1176 | Sept/Oct 2000 |
| Southern GM 2001 | 0.93 | 4.01 | 1.18 | 0.37 | 0.28 | 1558 | Sept/Oct 2001 |
| Southern GM 2002 | 1.23 | 6.19 | 1.53 | 0.33 | 0.20 | 1154 | Sept/Oct 2002 |

Table 3.1.3a. Lobster landings in MT by Statistical Districts (STD) for LFA 35.

| Season | STD79 | STD81 | STD24 | STD44 | STD43 | STD41 | STD40 | STD35 | STD39 | STD38 | LFA 35 Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1983-84 | 62.0 | 8.0 | 10.0 | 13.0 | 14.0 | 9.0 | 16.0 | 9.0 | 20.0 | 15.0 | **176.0** |
| 1984-85 | 76.0 | 10.0 | 13.0 | 20.0 | 19.0 | 8.0 | 24.0 | 17.0 | 28.0 | 17.0 | **232.0** |
| 1985-86 | 72.0 | 6.0 | 7.0 | 33.0 | 15.0 | 15.0 | 18.0 | 19.0 | 50.0 | 19.0 | **254.0** |
| 1986-87 | 99.0 | 7.0 | 11.0 | 44.0 | 19.0 | 15.0 | 28.0 | 16.0 | 78.0 | 18.0 | **335.0** |
| 1987-88 | 77.0 | 12.0 | 13.0 | 33.0 | 14.0 | 19.0 | 20.0 | 19.0 | 55.0 | 13.0 | **275.0** |
| 1988-89 | 84.0 | 6.5 | 15.0 | 31.3 | 20.0 | 20.1 | 32.7 | 15.3 | 41.2 | 13.0 | **279.1** |
| 1989-90 | 64.0 | 6.4 | 10.5 | 25.5 | 18.0 | 14.3 | 29.8 | 20.8 | 45.9 | 20.6 | **255.8** |
| 1990-91 | 42.1 | 0.9 | 4.0 | 26.9 | 27.0 | 9.4 | 25.9 | 24.9 | 52.0 | 20.2 | **233.3** |
| 1991-92 | 58.0 | 2.2 | 10.6 | 27.6 | 27.0 | 12.4 | 22.7 | 20.6 | 50.6 | 30.7 | **262.5** |
| 1992-93 | 61.5 | 4.6 | 10.9 | 36.1 | 24.0 | 7.5 | 23.7 | 16.9 | 32.0 | 23.7 | **240.8** |
| 1993-94 | 44.8 | 2.8 | 8.6 | 43.2 | 20.0 | 14.4 | 31.7 | 18.3 | 40.8 | 17.2 | **241.8** |
| 1994-95 | 24.8 | 1.7 | 19.5 | 62.4 | 33.0 | 29.2 | 53.4 | 18.1 | 45.2 | 21.9 | **309.3** |
| 1995-96 | 99.5 | 3.1 | 24.6 | 92.9 | 28.0 | 42.2 | 71.9 | 52.3 | 113.9 | 30.7 | **559.2** |
| 1996-97 | 147.4 | 6.9 | 32.8 | 145.4 | 25.0 | 66.4 | 63.5 | 66.0 | 153.0 | 42.4 | **748.8** |
| 1997-98 | 151.4 | 6.8 | 47.3 | 184.8 | 22.0 | 67.1 | 84.9 | 72.4 | 163.4 | 44.2 | **844.3** |
| 1998-99 | 164.5 | 5.1 | 48.6 | 198.6 | 23.4 | 37.0 | 96.6 | 128.0 | 184.2 | 70.1 | **956.0** |
| 1999-00 | 185.7 | 4.3 | 54.8 | 143.4 | 15.5 | 19.0 | 89.4 | 107.8 | 236.4 | 76.2 | **932.4** |
| 2000-01 | 213.8 | 5.8 | 47.5 | 164.6 | 25.3 | 15.9 | 87.6 | 117.7 | 290.6 | 123.4 | **1092.2** |
| 2001-02 | 234.2 | 5.5 | 37.0 | 157.1 | 19.1 | 32.5 | 100.2 | 153.3 | 286.5 | 226.0 | **1251.4** |
| 2002-03 | 179.5 | 8.8 | 38.4 | 128.4 | 21.9 | 28.8 | 99.9 | 139.6 | 288.9 | 281.8 | **1215.9** |
| 2003-04 | 154.7 | 7.1 | 33.8 | 127.0 | 24.2 | 27.6 | 96.0 | 121.0 | 308.9 | 416.0 | **1316.3** |
| 2004-05 | 162.4 | 7.3 | 25.0 | 118.1 | 23.7 | 29.8 | 114.2 | 105.9 | 319.1 | 220.8 | **1126.4** |
| 2005-06 | 141.8 | 5.9 | 17.0 | 112.5 | 19.3 | 26.8 | 92.9 | 87.2 | 219.2 | 250.5 | **973.3** |

Table 3.1.3b. Lobster landings in MT by Statistical Districts (STD) for LFAs 36 & 38

| Season | STD 48 | STD 49 | STD 51 | STD 52 | STD 53 | LFA 36 Total | LFA 38 STD 50 |
|---|---|---|---|---|---|---|---|
| 1983-84 | 56.0 | 42.0 | 50.0 | 27.0 | 37.0 | **212** | **364** |
| 1984-85 | 96.0 | 49.0 | 49.0 | 27.0 | 43.0 | **264** | **334** |
| 1985-86 | 82.0 | 65.0 | 61.0 | 22.0 | 50.0 | **280** | **316** |
| 1986-87 | 92.0 | 96.0 | 65.0 | 18.0 | 55.0 | **326** | **327** |
| 1987-88 | 86.0 | 112.0 | 73.0 | 21.0 | 44.0 | **336** | **384** |
| 1988-89 | 92.1 | 106.6 | 76.8 | 13.5 | 23.1 | **312** | **468** |
| 1989-90 | 67.3 | 88.1 | 45.3 | 1.8 | 18.4 | **221** | **466** |
| 1990-91 | 73.7 | 102.1 | 55.8 | 2.2 | 32.6 | **266** | **497** |
| 1991-92 | 64.0 | 100.0 | 54.1 | 1.6 | 28.0 | **248** | **511** |
| 1992-93 | 61.3 | 99.4 | 72.8 | 1.3 | 20.9 | **256** | **471** |
| 1993-94 | 75.5 | 92.3 | 83.7 | 2.8 | 20.5 | **275** | **520** |
| 1994-95 | 97.8 | 98.8 | 83.3 | 1.9 | 35.9 | **318** | **657** |
| 1995-96 | 142.5 | 123.0 | 104.4 | 11.1 | 32.8 | **414** | **600** |
| 1996-97 | 159.8 | 176.3 | 147.8 | 51.0 | 125.0 | **660** | **547** |
| 1997-98 | 213.0 | 181.0 | 147.0 | 57.0 | 153.0 | **751** | **696** |
| 1998-99 | 192.1 | 227.5 | 164.2 | 63.9 | 166.6 | **814** | **806** |
| 1999-00 | 172.8 | 236.6 | 191.0 | 63.7 | 198.6 | **863** | **826** |
| 2000-01 | 205.1 | 260.0 | 234.9 | 66.8 | 230.6 | **997** | **981** |
| 2001-02 | 202.5 | 298.0 | 368.9 | 96.2 | 270.1 | **1236** | **1144** |
| 2002-03 | 203.5 | 310.1 | 311.3 | 81.8 | 251.4 | **1158** | **1072** |
| 2003-04 | 177.3 | 263.8 | 355.1 | 97.4 | 253.7 | **1147** | **1133** |
| 2004-05 | 190.8 | 294.9 | 322.3 | 86.4 | 176.7 | **1071** | **1322** |
| 2005-06 | 216 | 270 | 312 | 86 | 158 | **1042** | **1289** |

Table 3.1.4a. Landings (Kg) from Bay of Fundy log books by seasons and Grid Groups for the last three fishing seasons (2003-04 to 2005-06).

| Time period | Season | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total (Kg) Reported | Total (Kg) landed | Percentage reported |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fall | 2003-04 | | 83112 | 46529 | 262005 | 89214 | 358205 | 2883 | 841948 | 2242462 | 38% |
| | 2004-05 | 89935 | 122783 | 151512 | 269577 | 104914 | 385149 | 6727 | 1130597 | 1848025 | 61% |
| | 2005-06 | 65007 | 167891 | 139531 | 375432 | 109810 | 550381 | 27497 | 1435549 | 2285709 | 63% |
| Winter | 2003-04 | | 490 | | 4596 | 20695 | 35469 | 292 | 61542 | 113005 | 54% |
| | 2004-05 | | 107 | | 3328 | 45535 | 37041 | 9761 | 95772 | 130288 | 74% |
| | 2005-06 | | 822 | | 4050 | 38712 | 29992 | 7635 | 81211 | 109532 | 74% |
| Spring | 2003-04 | 26481 | 128360 | 105000 | 135556 | 96699 | 191082 | 780 | 683958 | 1226125 | 56% |
| | 2004-05 | 114476 | 138314 | 231551 | 168756 | 177907 | 250636 | 6774 | 1088414 | 1510727 | 72% |
| | 2005-06 | 73016 | 80862 | 152463 | 126444 | 101386 | 154734 | | 688905 | 899648 | 77% |
| Total | 2003-04 | 26481 | 211962 | 151529 | 402157 | 206608 | 584756 | 3955 | 1587448 | 3583592 | 44% |
| | 2004-05 | 204411 | 261204 | 383063 | 441661 | 328356 | 672826 | 23262 | 2314783 | 3489040 | 66% |
| | 2005-06 | 138023 | 249575 | 291994 | 505926 | 249908 | 735107 | 35132 | 2205665 | 3294889 | 67% |

Table 3.1.4b. Proportion of landings from Bay of Fundy log books by seasons and Grid Groups for the last three fishing seasons (2003-04 to 2005-06).

| Time period | Season | 1 | 2 | 3 | 4 | 5 | 6 | 7 | LFA 35 (1 & 3) | LFA 36 (2 & 4) | LFA 38 Inshore (6) | LFA 36 & 38 Offshore (5 & 7) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fall | 2003-04 | 0% | 10% | 6% | 31% | 11% | 43% | 0% | 6% | 41% | 43% | 11% |
| | 2004-05 | 8% | 11% | 13% | 24% | 9% | 34% | 1% | 21% | 35% | 34% | 10% |
| | 2005-06 | 5% | 12% | 10% | 26% | 8% | 38% | 2% | 14% | 38% | 38% | 10% |
| Winter | 2003-04 | | 1% | | 7% | 34% | 58% | 0% | | 8% | 58% | 34% |
| | 2004-05 | | 0% | | 3% | 48% | 39% | 10% | | 4% | 39% | 58% |
| | 2005-06 | | 1% | | 5% | 48% | 37% | 9% | | 6% | 37% | 57% |
| Spring | 2003-04 | 4% | 19% | 15% | 20% | 14% | 28% | 0% | 19% | 39% | 28% | 14% |
| | 2004-05 | 11% | 13% | 21% | 16% | 16% | 23% | 1% | 32% | 28% | 23% | 17% |
| | 2005-06 | 11% | 12% | 22% | 18% | 15% | 22% | 0% | 33% | 30% | 22% | 15% |
| Total | 2003-04 | 2% | 13% | 10% | 25% | 13% | 37% | 0% | 11% | 39% | 37% | 13% |
| | 2004-05 | 9% | 11% | 17% | 19% | 14% | 29% | 1% | 25% | 30% | 29% | 15% |
| | 2005-06 | 6% | 11% | 13% | 23% | 11% | 33% | 2% | 19% | 34% | 33% | 13% |

Table 3.2a. Statistics on the number of trap haul (th) from Bay of Fundy logbooks, sorted by Grid Groups and time period for the last three fishing seasons (2003-04 to 2005-06).

| Time period | Season | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total (TH) Reported |
|---|---|---|---|---|---|---|---|---|---|
| Fall | 2003-04 | | 48474 | 22765 | 138721 | 45780 | 179678 | 1270 | 436688 |
| | 2004-05 | 47570 | 68966 | 132550 | 205892 | 61952 | 214997 | 2593 | 734520 |
| | 2005-06 | 24609 | 88529 | 90093 | 279506 | 71794 | 342060 | 20550 | 917141 |
| Winter | 2003-04 | | 586 | | 5418 | 24251 | 51195 | 820 | 82270 |
| | 2004-05 | | | | 4176 | 30508 | 59545 | 9335 | 103564 |
| | 2005-06 | | 984 | | 5572 | 29590 | 54111 | 9990 | 100247 |
| Spring | 2003-04 | 22697 | 121008 | 157293 | 164832 | 101793 | 342991 | 2380 | 912994 |
| | 2004-05 | 105594 | 133061 | 341281 | 214329 | 148061 | 484080 | 8330 | 1434736 |
| | 2005-06 | 78371 | 83232 | 258113 | 183487 | 105494 | 298007 | | 1006704 |
| Total | 2003-04 | 22697 | 170068 | 180058 | 308971 | 171824 | 573864 | 4470 | 1431952 |
| | 2004-05 | 153164 | 202027 | 473831 | 424397 | 240521 | 758622 | 20258 | 2272820 |
| | 2005-06 | 102980 | 172745 | 348206 | 468565 | 206878 | 694178 | 30540 | 2024092 |

Table 3.2b. Statistics on catch per unit of effort (CPUE) in number of kilograms per trap haul (Kg/th) from Bay of Fundy logbooks, sorted by Grid Groups and time period for the last three fishing seasons (2003-04 to 2005-06).

| Time period | Season | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total (CPUE) Reported |
|---|---|---|---|---|---|---|---|---|---|
| Fall | 2003-04 | | 1.7 | 2.0 | 1.9 | 1.9 | 2.0 | 2.3 | 1.9 |
| | 2004-05 | 1.9 | 1.8 | 1.1 | 1.3 | 1.7 | 1.8 | 2.6 | 1.5 |
| | 2005-06 | 2.6 | 1.9 | 1.5 | 1.3 | 1.5 | 1.6 | 1.3 | 1.6 |
| Winter | 2003-04 | | 0.8 | | 0.8 | 0.9 | 0.7 | 0.4 | 0.7 |
| | 2004-05 | | | | 0.8 | 1.5 | 0.6 | 1.0 | 0.9 |
| | 2005-06 | | 0.8 | | 0.7 | 1.3 | 0.6 | 0.8 | 0.8 |
| Spring | 2003-04 | 1.2 | 1.1 | 0.7 | 0.8 | 0.9 | 0.6 | 0.3 | 0.7 |
| | 2004-05 | 1.1 | 1.0 | 0.7 | 0.8 | 1.2 | 0.5 | 0.8 | 0.8 |
| | 2005-06 | 0.9 | 1.0 | 0.6 | 0.7 | 1.0 | 0.5 | | 0.7 |
| Total | 2003-04 | 1.2 | 1.2 | 0.8 | 1.3 | 1.2 | 1.0 | 0.9 | 1.1 |
| | 2004-05 | 1.3 | 1.3 | 0.8 | 1.0 | 1.4 | 0.9 | 1.1 | 1.0 |
| | 2005-06 | 1.3 | 1.4 | 0.8 | 1.1 | 1.2 | 1.1 | 1.2 | 1.1 |

Table 3.2c. Lobster catch rates in kilograms per trap haul (Kg/th) by two week periods from LFA's 35, 36 and 38 log book data, during the last three fishing seasons (2003-04 to 2005-06).

| Bi-weekly Periods | Date | LFA 35 (Kg/TH) | | | LFA 36 (kg/TH) | | | LFA38 (Kg/TH) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Season | | | Season | | | Season | | |
| | | 2003-04 | 2004-25 | 2005-06 | 2003-04 | 2004-25 | 2005-06 | 2003-04 | 2004-25 | 2005-06 |
| 1 | Oct 15-31 | 2.2 | 1.5 | 2.0 | | | | | | |
| 2 | Nov 1-15 | 1.2 | 1.3 | 1.4 | 3.0 | 2.3 | 2.5 | 3.0 | 2.8 | 2.6 |
| 3 | Nov 16-30 | 1.0 | 1.0 | 1.0 | 2.2 | 1.5 | 1.6 | 2.2 | 1.7 | 1.5 |
| 4 | Dec 1-15 | 0.7 | 0.7 | 0.8 | 1.3 | 0.9 | 1.0 | 1.7 | 1.3 | 1.1 |
| 5 | Dec 16-31 | 0.2 | 1.1 | 0.6 | 1.0 | 0.7 | 0.7 | 1.2 | 1.2 | 1.0 |
| 6 | Jan 1-15 | | | | | 0.9 | 0.8 | 1.1 | 1.2 | 0.8 |
| 7 | Jan 16-31 | | | | | | | 1.1 | 1.2 | 0.9 |
| 8 | Feb 1-15 | | | | | | | 0.8 | 0.8 | 0.8 |
| 9 | Feb 16-28 | | | | | | | 0.9 | 0.8 | 0.8 |
| 10 | Mar 1-15 | | | | | | | 0.5 | 0.4 | 0.5 |
| 11 | Mar 16-31 | | | | | | | 0.4 | 0.5 | 0.6 |
| 12 | Apr 1-15 | 0.1 | 0.8 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 |
| 13 | Apr 16-30 | 0.2 | 0.3 | 0.2 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 |
| 14 | May 1-15 | 0.4 | 0.6 | 0.5 | 0.4 | 0.5 | 0.5 | 0.4 | 0.6 | 0.6 |
| 15 | May 16-31 | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 | 0.6 | 0.6 | 0.8 | 0.7 |
| 16 | Jun 1-15 | 0.5 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 0.8 | 0.8 |
| 17 | Jun 16-30 | 0.8 | 0.9 | 0.9 | 1.2 | 1.2 | 1.1 | 0.9 | 0.9 | 0.8 |
| 18 | Jul 1-15 | 0.9 | 1.0 | 0.9 | | | | | | |
| 19 | Jul 16-31 | 1.0 | 1.0 | 0.8 | | | | | | |

Table 4.1.1. Statistics showing the total number of days fished during each fishing season, the average number of days fished per licence and the number of licences per LFA during the last four fishing seasons (2002-03 to 2005-06).

| | LFA 35 | | |
|---|---|---|---|
| Season | Days fished | Nb Licences | Days /Licence |
| 2002-03 | 5150 | 91 | 57 |
| 2003-04 | 5081 | 90 | 56 |
| 2004-05 | 5202 | 88 | 59 |
| 2005-06 | 4445 | 87 | 51 |

| | LFA 36 | | |
|---|---|---|---|
| Season | Days fished | Nb Licences | Days /Licence |
| 2002-03 | 5730 | 138 | 42 |
| 2003-04 | 5249 | 128 | 41 |
| 2004-05 | 5858 | 138 | 42 |
| 2005-06 | 5779 | 137 | 42 |

| | LFA 38 | | |
|---|---|---|---|
| Season | Days fished | Nb Licences | Days /Licence |
| 2002-03 | 4444 | 81 | 55 |
| 2003-04 | 4536 | 75 | 60 |
| 2004-05 | 5507 | 93 | 59 |
| 2005-06 | 5326 | 104 | 51 |

Table 4.2a. Statistics on the total number of legal size lobsters landed and the proportion of lobsters in each Molt Group (Molt 1= 83-94 mm CL, Molt 2= 95-109 mm CL and Molt 3= 110 + mm CL) sorted by Grid Groups for the Fall, Winter and Spring time periods during the 2004-05 fishing Season. Also included is numbers and proportion of lobsters over the size at 50% maturity (>104 mm CL).

| 2004-05 Fall Season | Grid Groups | | | | | | | BOF |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
| # Molt Group 1 | 65399 | 83625 | 85405 | 263699 | 4536 | 588357 | 10276 | 1101297 |
| # Molt Group 2 | 39928 | 44063 | 60794 | 86541 | 19942 | 73914 | 1291 | 326473 |
| # Molt Group 3 | 15663 | 24905 | 38271 | 38955 | 42536 | 8870 | 155 | 169356 |
| # >Size at 50% maturity | 24419 | 34006 | 53625 | 57774 | 50538 | 14044 | 245 | 234651 |
| Total | 120990 | 152594 | 184470 | 389195 | 67013.8 | 671141 | 11722 | 1597126 |
| | | | | | | | | |
| % Molt Group 1 | 54% | 55% | 46% | 68% | 7% | 88% | 88% | 69% |
| % Molt Group 2 | 33% | 29% | 33% | 22% | 30% | 11% | 11% | 20% |
| % Molt Group 3 | 13% | 16% | 21% | 10% | 63% | 1% | 1% | 11% |
| % Size at 50% maturity | 20% | 22% | 29% | 15% | 75% | 2% | 2% | 15% |

| 2004-05 Winter Season | Grid Groups | | | | | | | BOF |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
| # Molt Group 1 | | 73 | | 3255 | 1969 | 56584 | 14911 | 76792 |
| # Molt Group 2 | | 38 | | 1068 | 8655 | 7109 | 1873 | 18744 |
| # Molt Group 3 | | 22 | | 481 | 18462 | 853 | 225 | 20042 |
| # >Size at 50% maturity | | 30 | | 713 | 21935 | 1351 | 356 | 24384 |
| Total | | 133 | | 4805 | 29085 | 64546 | 17009 | 115578 |
| | | | | | | | | |
| % Molt Group 1 | | 55% | | 68% | 7% | 88% | 88% | 66% |
| % Molt Group 2 | | 29% | | 22% | 30% | 11% | 11% | 16% |
| % Molt Group 3 | | 16% | | 10% | 63% | 1% | 1% | 17% |
| % Size at 50% maturity | | 22% | | 15% | 75% | 2% | 2% | 21% |

| 2004-05 Spring Season | Grid Groups | | | | | | | BOF |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
| # Molt Group 1 | 83021 | 112254 | 124526 | 141142 | 6016 | 303148 | 8193 | 778300 |
| # Molt Group 2 | 46913 | 54907 | 74892 | 68317 | 36743 | 77043 | 2082 | 360897 |
| # Molt Group 3 | 21979 | 20471 | 68137 | 24670 | 77139 | 18842 | 509 | 231747 |
| # >Size at 50% maturity | 30660 | 31046 | 85759 | 38903 | 94758 | 29310 | 792 | 311227 |
| Total | 151913 | 187631 | 267555 | 234130 | 119898 | 399033 | 10785 | 1370944 |
| | | | | | | | | |
| % Molt Group 1 | 55% | 60% | 47% | 60% | 5% | 76% | 76% | 57% |
| % Molt Group 2 | 31% | 29% | 28% | 29% | 31% | 19% | 19% | 26% |
| % Molt Group 3 | 14% | 11% | 25% | 11% | 64% | 5% | 5% | 17% |
| % Size at 50% maturity | 20% | 17% | 32% | 17% | 79% | 7% | 7% | 23% |

| 2004-05 Season Total | Grid Groups | | | | | | | BOF |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
| # Molt Group 1 | 148420 | 195951 | 209931 | 408096 | 12521 | 948089 | 33380 | 1956389 |
| # Molt Group 2 | 86841 | 99008 | 135686 | 155927 | 65339 | 158066 | 5246 | 706114 |
| # Molt Group 3 | 37642 | 45399 | 106408 | 64107 | 138136 | 28565 | 889 | 421145 |
| # >Size at 50% maturity | 55078 | 65081 | 139384 | 97390 | 167231 | 44704 | 1393 | 570262 |
| Total | 272903 | 340358 | 452025 | 628130 | 215997 | 1134719 | 39516 | 3083648 |
| | | | | | | | | |
| % Molt Group 1 | 54% | 58% | 46% | 65% | 6% | 84% | 84% | 63% |
| % Molt Group 2 | 32% | 29% | 30% | 25% | 30% | 14% | 13% | 23% |
| % Molt Group 3 | 14% | 13% | 24% | 10% | 64% | 3% | 2% | 14% |
| % Size at 50% maturity | 20% | 19% | 31% | 16% | 77% | 4% | 4% | 18% |

Table 4.2b. Statistics on the total number of legal size females landed and the proportion of lobsters in each Molt Group (Molt 1= 83-94 mm CL, Molt 2= 95-109 mm CL and Molt 3= 110 + mm CL) sorted by Grid Groups for the Fall, Winter and Spring time periods during the 2004-05 fishing Season. Also included is numbers and proportion of females over the size at 50% maturity (> 104 mm CL).

| Females 2004-05 Fall Season | Grid Groups | | | | | | | BOF Total |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| # Molt Group 1 | 32302 | 40998 | 47303 | 136284 | 3851 | 281613 | 4919 | 547270 |
| # Molt Group 2 | 16562 | 20882 | 35167 | 44229 | 15748 | 20696 | 361 | 153645 |
| # Molt Group 3 | 3672 | 8046 | 14168 | 18099 | 17588 | 1478 | 26 | 63078 |
| # >Size at 50% maturity | 6599 | 12453 | 23200 | 30086 | 23707 | 3696 | 65 | 99805 |
| Total | 52535 | 69927 | 96637.9 | 198613 | 37187.1 | 303787 | 5305.94 | 763993 |
| | | | | | | | | |
| % Molt Group 1 | 61% | 59% | 49% | 69% | 10% | 93% | 93% | 72% |
| % Molt Group 2 | 32% | 30% | 36% | 22% | 42% | 7% | 7% | 20% |
| % Molt Group 3 | 7% | 12% | 15% | 9% | 47% | 0% | 0% | 8% |
| % Size at 50% maturity | 13% | 18% | 24% | 15% | 64% | 1% | 1% | 13% |

| Females 2004-05 Winter Season | Grid Groups | | | | | | | BOF Total |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| # Molt Group 1 | | 36 | | 1682 | 1672 | 27084 | 7137 | 37610 |
| # Molt Group 2 | | 18 | | 546 | 6835 | 1990 | 525 | 9914 |
| # Molt Group 3 | | 7 | | 223 | 7634 | 142 | 37 | 8044 |
| # >Size at 50% maturity | | 11 | | 371 | 10289 | 355 | 94 | 11121 |
| Total | | 61 | | 2452 | 16140 | 29216 | 7699 | 55568 |
| | | | | | | | | |
| % Molt Group 1 | | 59% | | 69% | 10% | 93% | 93% | 68% |
| % Molt Group 2 | | 30% | | 22% | 42% | 7% | 7% | 18% |
| % Molt Group 3 | | 12% | | 9% | 47% | 0% | 0% | 14% |
| % Size at 50% maturity | | 18% | | 15% | 64% | 1% | 1% | 20% |

| Females 2004-05 Spring Season | Grid Groups | | | | | | | BOF Total |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| # Molt Group 1 | 41003 | 60872 | 63144 | 80178 | 5587 | 177115 | 4787 | 432685 |
| # Molt Group 2 | 18747 | 28063 | 35537 | 32498 | 31371 | 36428 | 985 | 183629 |
| # Molt Group 3 | 1662 | 3525 | 10867 | 5693 | 34379 | 3768 | 102 | 59996 |
| # >Size at 50% maturity | 3694 | 7592 | 17915 | 12810 | 49205 | 8793 | 238 | 100247 |
| Total | 61412 | 92460 | 109548 | 118369 | 71337 | 217312 | 5873 | 676311 |
| | | | | | | | | |
| % Molt Group 1 | 67% | 66% | 58% | 68% | 8% | 82% | 82% | 64% |
| % Molt Group 2 | 31% | 30% | 32% | 27% | 44% | 17% | 17% | 27% |
| % Molt Group 3 | 3% | 4% | 10% | 5% | 48% | 2% | 2% | 9% |
| % Size at 50% maturity | 6% | 8% | 16% | 11% | 69% | 4% | 4% | 15% |

| Females 2004-05 Season Total | Grid Groups | | | | | | | BOF Total |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| # Molt Group 1 | 73304 | 101906 | 110447 | 218145 | 11110 | 485812 | 16843 | 1017566 |
| # Molt Group 2 | 35308 | 48964 | 70704 | 77274 | 53954 | 59114 | 1871 | 347188 |
| # Molt Group 3 | 5334 | 11578 | 25035 | 24016 | 59601 | 5389 | 165 | 131118 |
| # >Size at 50% maturity | 10293 | 20056 | 41115 | 43267 | 83202 | 12844 | 396 | 211172 |
| Total | 113947 | 162448 | 206186 | 319434 | 124664 | 550315 | 18878 | 1495872 |
| | | | | | | | | |
| % Molt Group 1 | 64% | 63% | 54% | 68% | 9% | 88% | 89% | 68% |
| % Molt Group 2 | 31% | 30% | 34% | 24% | 43% | 11% | 10% | 23% |
| % Molt Group 3 | 5% | 7% | 12% | 8% | 48% | 1% | 1% | 9% |
| % Size at 50% maturity | 9% | 12% | 20% | 14% | 67% | 2% | 2% | 14% |

Table 4.2c. Statistics on the total number of legal size males landed and the proportion of lobsters in each Molt Group (Molt 1= 83-94 mm CL, Molt 2= 95-109 mm CL and Molt 3= 110 + mm CL) sorted by Grid Groups for the Fall, Winter and Spring time periods during the 2004-05 fishing Season. Also included is numbers and proportion of males over the size at 50% maturity (> 104 mm CL).

| Males 2004-05 Fall Season | Grid Groups | | | | | | | BOF |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
| # Molt Group 1 | 33098 | 42627 | 38102 | 127414 | 685 | 306744 | 5358 | 554027 |
| # Molt Group 2 | 23366 | 23181 | 25627 | 42312 | 4194 | 53218 | 930 | 172828 |
| # Molt Group 3 | 11991 | 16859 | 24103 | 20856 | 24948 | 7391 | 129 | 106278 |
| # >Size at 50% maturity | 17820 | 21553 | 30425 | 27688 | 26831 | 10348 | 181 | 134846 |
| Total | 68455 | 82667 | 87832 | 190582 | 29827 | 367354 | 6416 | 833133 |
| | | | | | | | | |
| % Molt Group 1 | 48% | 52% | 43% | 67% | 2% | 84% | 84% | 66% |
| % Molt Group 2 | 34% | 28% | 29% | 22% | 14% | 14% | 14% | 21% |
| % Molt Group 3 | 18% | 20% | 27% | 11% | 84% | 2% | 2% | 13% |
| % Size at 50% maturity | 26% | 26% | 35% | 15% | 90% | 3% | 3% | 16% |

| Males 2004-05 Winter Season | Grid Groups | | | | | | | BOF |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
| # Molt Group 1 | | 37 | | 1573 | 297 | 29501 | 7774 | 39182 |
| # Molt Group 2 | | 20 | | 522 | 1820 | 5118 | 1349 | 8830 |
| # Molt Group 3 | | 15 | | 257 | 10828 | 711 | 187 | 11998 |
| # >Size at 50% maturity | | 19 | | 342 | 11645 | 995 | 262 | 13263 |
| Total | | 72 | | 2353 | 12945 | 35330 | 9310 | 60010 |
| | | | | | | | | |
| % Molt Group 1 | | 52% | | 67% | 2% | 84% | 84% | 65% |
| % Molt Group 2 | | 28% | | 22% | 14% | 14% | 14% | 15% |
| % Molt Group 3 | | 20% | | 11% | 84% | 2% | 2% | 20% |
| % Size at 50% maturity | | 26% | | 15% | 90% | 3% | 3% | 22% |

| Males 2004-05 Spring Season | Grid Groups | | | | | | | BOF |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
| # Molt Group 1 | 42018 | 51382 | 61382 | 60964 | 430 | 126032 | 3406 | 345614 |
| # Molt Group 2 | 28166 | 26843 | 39355 | 35819 | 5372 | 40615 | 1098 | 177268 |
| # Molt Group 3 | 20317 | 16946 | 57270 | 18977 | 42759 | 15074 | 407 | 171751 |
| # >Size at 50% maturity | 26966 | 23454 | 67843 | 26093 | 45553 | 20517 | 555 | 210980 |
| Total | 90501 | 95171 | 158007 | 115760 | 48561 | 181721 | 4911 | 694633 |
| | | | | | | | | |
| % Molt Group 1 | 46% | 54% | 39% | 53% | 1% | 69% | 69% | 50% |
| % Molt Group 2 | 31% | 28% | 25% | 31% | 11% | 22% | 22% | 26% |
| % Molt Group 3 | 22% | 18% | 36% | 16% | 88% | 8% | 8% | 25% |
| % Size at 50% maturity | 30% | 25% | 43% | 23% | 94% | 11% | 11% | 30% |

| Males 2004-05 Season Total | Grid Groups | | | | | | | BOF |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
| # Molt Group 1 | 75116 | 94046 | 99484 | 189951 | 1412 | 462277 | 16538 | 938823 |
| # Molt Group 2 | 51532 | 50045 | 64982 | 78653 | 11386 | 98951 | 3376 | 358925 |
| # Molt Group 3 | 32308 | 33820 | 81373 | 40091 | 78536 | 23176 | 724 | 290028 |
| # > Size at 50% maturity | 44786 | 45026 | 98268 | 54124 | 84029 | 31860 | 998 | 359090 |
| Total | 158956 | 177910 | 245840 | 308695 | 91333 | 584404 | 20638 | 1587776 |
| | | | | | | | | |
| % Molt Group 1 | 47% | 53% | 40% | 62% | 2% | 79% | 80% | 59% |
| % Molt Group 2 | 32% | 28% | 26% | 25% | 12% | 17% | 16% | 23% |
| % Molt Group 3 | 20% | 19% | 33% | 13% | 86% | 4% | 4% | 18% |
| % Size at 50% maturity | 28% | 25% | 40% | 18% | 92% | 5% | 5% | 23% |

Table 4.2d. Statistics comparing the total number and the proportion of legal size lobsters landed within each Molt Group (Molt 1= 83-94 mm CL, Molt 2= 95-109 mm CL and Molt 3= 110 + mm CL) for each BOF LFA and LFA 34, during the 2004-05 fishing season and the previous assessment during the 1998-99 and 1999-00 fishing seasons.

| Season | Molt Groups (mm CL) | LFA 35 | | LFA 36 | | LFA 38 | | Total BOF | | LFA 34 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Landed per Molt Group | Percentage per Molt Group | No. Landed per Molt Group | Percentage per Molt Group | No. Landed per Molt Group | Percentage per Molt Group | No. Landed per Molt Group | Percentage per Molt Group | No. Landed per Molt Group | Percentage per Molt Group |
| 2004-05 | 83-94 | 759,683 | 51% | 922,342 | 62% | 781,495 | 55% | 2,463,521 | 56% | 18,675,059 | 80% |
| | 95-109 | 467,554 | 32% | 380,652 | 26% | 295,242 | 21% | 1,143,448 | 26% | 3,375,173 | 15% |
| | 110+ | 254,246 | 17% | 172,977 | 12% | 345,361 | 24% | 772,584 | 18% | 1,085,192 | 5% |
| **Total** | | **1,481,484** | **34%** | **1,475,971** | **34%** | **1,422,098** | **32%** | **4,379,553** | | **23,135,424** | |
| 1998-99 | 81-94 | 919,119 | 64% | 834,205 | 70% | 623,397 | 66% | 2,376,721 | 66% | 16,781,765 | 83% |
| | 95-109 | 402,145 | 28% | 254,439 | 21% | 169,368 | 18% | 825,952 | 23% | 2,629,123 | 13% |
| | 110+ | 116,741 | 8% | 109,365 | 9% | 151,609 | 16% | 377,715 | 11% | 737,529 | 4% |
| **Total** | | **1,438,005** | **40%** | **1,198,009** | **33%** | **944,374** | **26%** | **3,580,388** | | **20,148,417** | |
| 1999-00 | 81-94 | 829,325 | 63% | 700,961 | 65% | 664,352 | 68% | 2,194,638 | 65% | 17,042,984 | 85% |
| | 95-109 | 394,101 | 30% | 253,005 | 24% | 171,223 | 18% | 818,329 | 24% | 2,484,936 | 12% |
| | 110+ | 94,546 | 7% | 122,943 | 11% | 139,268 | 14% | 356,757 | 11% | 649,121 | 3% |
| **Total** | | **1,317,972** | **39%** | **1,076,909** | **32%** | **974,843** | **29%** | **3,369,724** | | **20,177,041** | |

Table 4.3a. Sample output of the length based Cohort Analysis for the Bay of Fundy female lobsters using natural mortality M = 0.10 The (TOP) estimate is based on 11 mm size grouping and on growth and maturity data. The (Bottom) estimate is based on 5 mm groupings except 10 mm groupings for large lobsters and on the egg per recruit model.

BOF females, 2004-05 fishing season

LENGTH-BASED COHORT ANALYSIS

| | | | | | | | | | (INPUT) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Terminal F = | 0.2 | 07/03/2007 |
| | | | | | | | | Natural Mortality (m)= | 0.1 | |
| | | | | | | | | Tc = | 0.33 | |
| Length (mm) | | | (INPUT) Catch (numbers) | (INPUT) Delta-t (y) | Stock Numbers | Mean Number | F/Z | Z | F | F*C |
| 182 | | 192 | 123 | 3.86 | 185 | | | | | |
| 171 | # | 181 | 294 | 3.64 | 597 | 1185 | 0.71 | 0.35 | 0.25 | 73 |
| 160 | - | 170 | 421 | 3.42 | 1312 | 2936 | 0.59 | 0.24 | 0.14 | 60 |
| 149 | - | 159 | 2467 | 3.20 | 4548 | 7694 | 0.76 | 0.42 | 0.32 | 791 |
| 138 | - | 148 | 5088 | 2.95 | 11714 | 20776 | 0.71 | 0.34 | 0.24 | 1246 |
| 127 | - | 137 | 16456 | 2.91 | 33783 | 56132 | 0.75 | 0.39 | 0.29 | 4824 |
| 116 | - | 126 | 52551 | 2.26 | 98986 | 126523 | 0.81 | 0.52 | 0.42 | 21827 |
| 105 | - | 115 | 133712 | 1.94 | 262777 | 300798 | 0.82 | 0.54 | 0.44 | 59438 |
| 94 | - | 104 | 330059 | 1.28 | 643035 | 501984 | 0.87 | 0.76 | 0.66 | 217018 |
| 83 | - | 93 | 954641 | 1.00 | 1697545 | 998693 | 0.91 | 1.06 | 0.96 | 912531 |
| Total | | | 1,495,811 | | 2,754,482 | 2,016,722 | Wtd.Ave.F = | | 0.81 | 1217808 |
| | | | | | | | A= | | 0.56 | |

Bay Of Fundy females, 2004-05 fishing season

LENGTH-BASED COHORT ANALYSIS

| | | | | | | | | | (INPUT) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Terminal F = | 0.2 | 07/03/2007 |
| | | | | | | | | Natural Mortality (m)= | 0.1 | |
| | | | | | | | | Tc = | 0.33 | |
| Length (mm) | | | (INPUT) Catch (numbers) | (INPUT) Delta-t (y) | Stock Numbers | Mean Number | F/Z | Z | F | F*C |
| 172 | # | 181 | 279 | 2.05 | 418 | | | | | |
| 162 | # | 171 | 344 | 2.05 | 881 | 1194 | 0.74 | 0.39 | 0.29 | 99 |
| 152 | # | 161 | 1599 | 2.05 | 2793 | 3131 | 0.84 | 0.61 | 0.51 | 816 |
| 142 | # | 151 | 3009 | 1.98 | 6618 | 8160 | 0.79 | 0.47 | 0.37 | 1109 |
| 132 | # | 141 | 9122 | 0.95 | 16689 | 9491 | 0.91 | 1.06 | 0.96 | 8767 |
| 122 | # | 131 | 27984 | 0.89 | 47059 | 23854 | 0.92 | 1.27 | 1.17 | 32830 |
| 117 | - | 121 | 28705 | 0.82 | 80595 | 48311 | 0.86 | 0.69 | 0.59 | 17056 |
| 112 | - | 116 | 38423 | 0.77 | 126450 | 74331 | 0.84 | 0.62 | 0.52 | 19861 |
| 107 | - | 111 | 67946 | 0.69 | 205052 | 106549 | 0.86 | 0.74 | 0.64 | 43329 |
| 102 | - | 106 | 87251 | 0.60 | 306762 | 144594 | 0.86 | 0.70 | 0.60 | 52649 |
| 97 | - | 101 | 115295 | 0.52 | 440544 | 184867 | 0.86 | 0.72 | 0.62 | 71906 |
| 92 | - | 96 | 276082 | 0.48 | 742418 | 257925 | 0.91 | 1.17 | 1.07 | 295517 |
| 87 | - | 91 | 326647 | 0.47 | 1110075 | 410100 | 0.89 | 0.90 | 0.80 | 260176 |
| 82 | - | 86 | 588221 | 0.47 | 1760909 | 626135 | 0.90 | 1.04 | 0.94 | 552603 |
| Total | | | 1,570,906 | | 4,847,264 | 1,898,641 | Wtd.Ave.F = | | 0.86 | 1356719 |
| | | | | | | | A= | | 0.58 | |

Table 4.3b. Sample output of the length based Cohort Analysis for the Bay of Fundy females using natural mortality M = 0.15. The (TOP) estimate is based on 11 mm size grouping and on growth and maturity data. The (Bottom) estimate is based on 5 mm groupings, except 10 mm groupings for large lobsters, and on the egg per recruit model.

## BOF females, 2004-05 fishing season

LENGTH-BASED COHORT ANALYSIS

| | (INPUT) |
|---|---|
| Terminal F = | 0.2 |
| Natural Mortality (m)= | 0.15 |
| Tc = | 0.33 |

07/03/2007

| Length (mm) | | | (INPUT) Catch (numbers) | (INPUT) Delta-t (y) | Stock Numbers | Mean Number | F/Z | Z | F | F*C |
|---|---|---|---|---|---|---|---|---|---|---|
| 182 | | 192 | 123 | 3.86 | 215 | | | | | |
| 171 | # | 181 | 294 | 3.64 | 723 | 1429 | 0.58 | 0.36 | 0.21 | 60 |
| 160 | - | 170 | 421 | 3.42 | 1707 | 3750 | 0.43 | 0.26 | 0.11 | 47 |
| 149 | - | 159 | 2467 | 3.20 | 5649 | 9834 | 0.63 | 0.40 | 0.25 | 619 |
| 138 | - | 148 | 5088 | 2.95 | 14676 | 26252 | 0.56 | 0.34 | 0.19 | 986 |
| 127 | - | 137 | 16456 | 2.91 | 41709 | 70515 | 0.61 | 0.38 | 0.23 | 3840 |
| 116 | - | 126 | 52551 | 2.26 | 117343 | 153889 | 0.69 | 0.49 | 0.34 | 17945 |
| 105 | - | 115 | 133712 | 1.94 | 304252 | 354654 | 0.72 | 0.53 | 0.38 | 50412 |
| 94 | - | 104 | 330059 | 1.28 | 720434 | 574152 | 0.79 | 0.72 | 0.57 | 189740 |
| 83 | - | 93 | 954641 | 1.00 | 1840468 | 1102621 | 0.85 | 1.02 | 0.87 | 826520 |
| Total | | | 1,495,811 | | 3,047,176 | 2,297,097 | Wtd.Ave.F = | | 0.73 | 1090170 |
| | | | | | | | A= | | 0.52 | |

## Bay Of Fundy females, 2004-05 fishing season

LENGTH-BASED COHORT ANALYSIS

| | (INPUT) |
|---|---|
| Terminal F = | 0.2 |
| Natural Mortality (m)= | 0.15 |
| Tc = | 0.33 |

07/03/2007

| Length (mm) | | | (INPUT) Catch (numbers) | (INPUT) Delta-t (y) | Stock Numbers | Mean Number | F/Z | Z | F | F*C |
|---|---|---|---|---|---|---|---|---|---|---|
| 172 | # | 181 | 279 | 2.05 | 488 | | | | | |
| 162 | # | 171 | 344 | 2.05 | 1044 | 1419 | 0.62 | 0.39 | 0.24 | 83 |
| 152 | # | 161 | 1599 | 2.05 | 3191 | 3654 | 0.74 | 0.59 | 0.44 | 700 |
| 142 | # | 151 | 3009 | 1.98 | 7616 | 9437 | 0.68 | 0.47 | 0.32 | 959 |
| 132 | # | 141 | 9122 | 0.95 | 18341 | 10692 | 0.85 | 1.00 | 0.85 | 7782 |
| 122 | # | 131 | 27984 | 0.89 | 50202 | 25843 | 0.88 | 1.23 | 1.08 | 30303 |
| 117 | - | 121 | 28705 | 0.82 | 86704 | 51976 | 0.79 | 0.70 | 0.55 | 15853 |
| 112 | - | 116 | 38423 | 0.77 | 137223 | 80648 | 0.76 | 0.63 | 0.48 | 18305 |
| 107 | - | 111 | 67946 | 0.69 | 222588 | 116125 | 0.80 | 0.74 | 0.59 | 39756 |
| 102 | - | 106 | 87251 | 0.60 | 333490 | 157668 | 0.79 | 0.70 | 0.55 | 48284 |
| 97 | - | 101 | 115295 | 0.52 | 479039 | 201696 | 0.79 | 0.72 | 0.57 | 65906 |
| 92 | - | 96 | 276082 | 0.48 | 797066 | 279635 | 0.87 | 1.14 | 0.99 | 272574 |
| 87 | - | 91 | 326647 | 0.47 | 1189913 | 441331 | 0.83 | 0.89 | 0.74 | 241764 |
| 82 | - | 86 | 588221 | 0.47 | 1878896 | 671747 | 0.85 | 1.03 | 0.88 | 515080 |
| Total | | | 1,570,906 | | 5,205,800 | 2,051,871 | Wtd.Ave.F = | | 0.80 | 1257351 |
| | | | | | | | A= | | 0.55 | |

Table 6.1 Indicator Tables The symbols gives the direction of the change rather than whether it is positive or negative for the fishery ("+" is higher relative to the previous period. "-" is lower and "O" is no change detectable).

Abundance indicators of legal size lobsters by molt group and landings comparison between the recent fall and spring at-sea sampling period (2002-06) and the previous fall and spring at-sea sampling period (1997-2001)

| Catch rate of legal size by molt group from sea sampling at four representative ports | Alma | Dipper Harbour | North Head | Seal Cove |
|---|---|---|---|---|
| Fall (five year average # lob/th) | | | | |
| 1st molt (83-94 mm CL) 1997-01 vs 2002-06 | - | + | + | + |
| 2nd molt (95-109 mm CL) 1997-01 vs 2002-06 | - | + | + | + |
| 3rd molt (110 + mm CL) 1997-01 vs 2002-06 | - | + | + | 0 |
| Spring (five year average # lob/th) | | | | |
| 1st molt (83-94 mm CL) 1997-01 vs 2002-06 | - | - | + | + |
| 2nd molt (95-109 mm CL) 1997-01 vs 2002-06 | 0 | - | + | + |
| 3rd molt (110 + mm CL) 1997-01 vs 2002-06 | + | - | - | + |
| | | | | |
| Lobster landings within each LFA | LFA 35 | LFA 36 | LFA 38 | Total BOF |
| 1996-2001 vs 2001-2006 fishing seasons | + | + | + | + |

Fishing pressure indicators comparing the proportion of lobsters in each molt group between the last assessment (1998-99 and 1999-00) and the present estimates (2004-05).

| 1998-99 and 1999-00 vs 2004-05 | LFA 35 | LFA 36 | LFA 38 | BOF Total |
|---|---|---|---|---|
| % in 1st molt group (81-83 to 94 mm CL) | -- | -- | -- | -- |
| % in 2nd molt group (95- 109 mm CL) | + | + | + | + |
| % in 3rd molt group (110 + mm CL) | + | + | + | + |

Production indicator comparison of the average catch rates of pre-recruits between the recent fall and spring at-sea sampling period (2002-06) and the previous fall and spring period (1997-2001).

**Production–Pre-recruits:**

| Catch rate of pre-recruits (75-80 & 77-82 mm CL) from sea sampling at five representative ports. | Alma (LFA 35) | Victoria Beach (LFA 35) | Delap Cove (LFA 35) | Dipper Harbour (LFA 36) | Seal Cove (LFA 38) |
|---|---|---|---|---|---|
| Fall (five year average # lob/th) 1997-01 vs. 2002-06 | - | + | 0 | - | + |
| Spring (five year average # lob/th) 1997-01 vs. 2002-06 | - | + | + | - | + |

Production indicators comparing the average catch rates from at-sea sampling of berried females during July between the recent reference period (2002-06) and the previous period (1997-2001).

**Production–Berried Females:**

| Catch rate of berried females from sea sampling at four representative ports in LFA 35, during July. | Alma | Advocate | Delap Cove | Victoria Beach |
|---|---|---|---|---|
| Five year average # lob/th 1997-01 vs. 2002-06 | + | + | + | + |

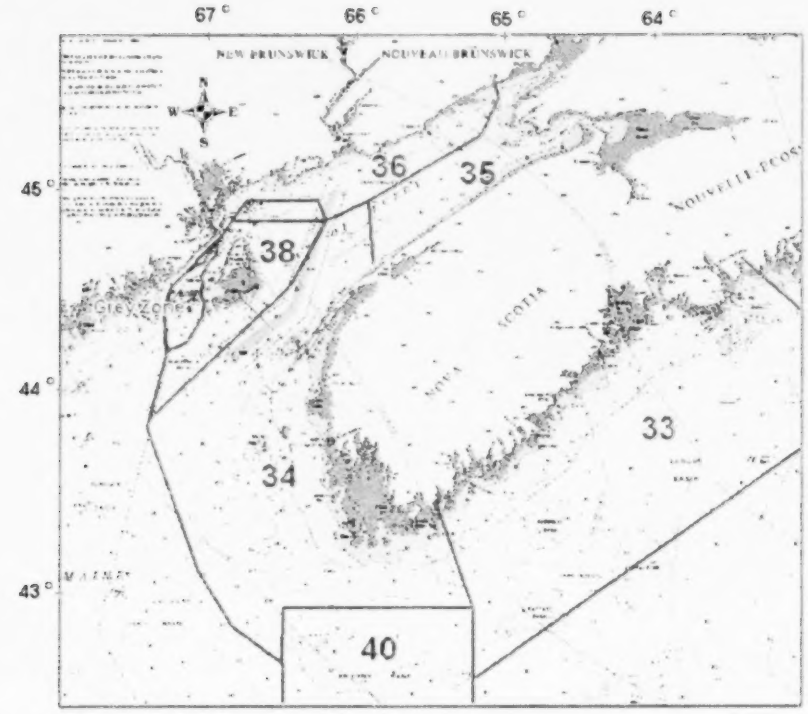


Figure 1. Bay of Fundy/ Gulf of Maine map showing LFA's 35, 36, 38, the Grey Zone (LFA 38B) and adjacent LFA 34.

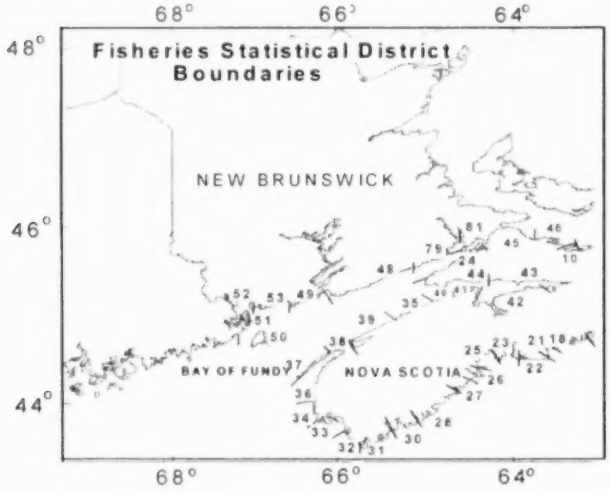


Figure 2.1. Statistical Districts (S.D.)

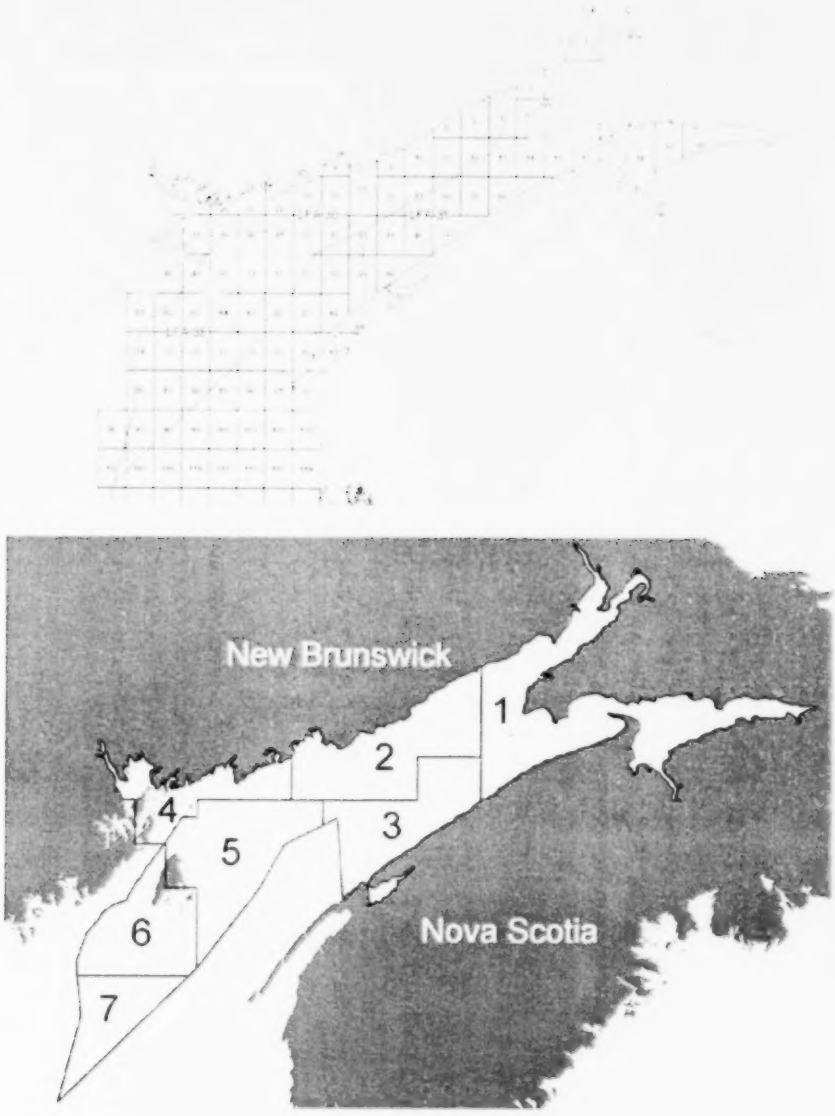


Figure 2.1.1. Logbook grids (Top), and Grid Groups (bottom) for the Bay of Fundy.

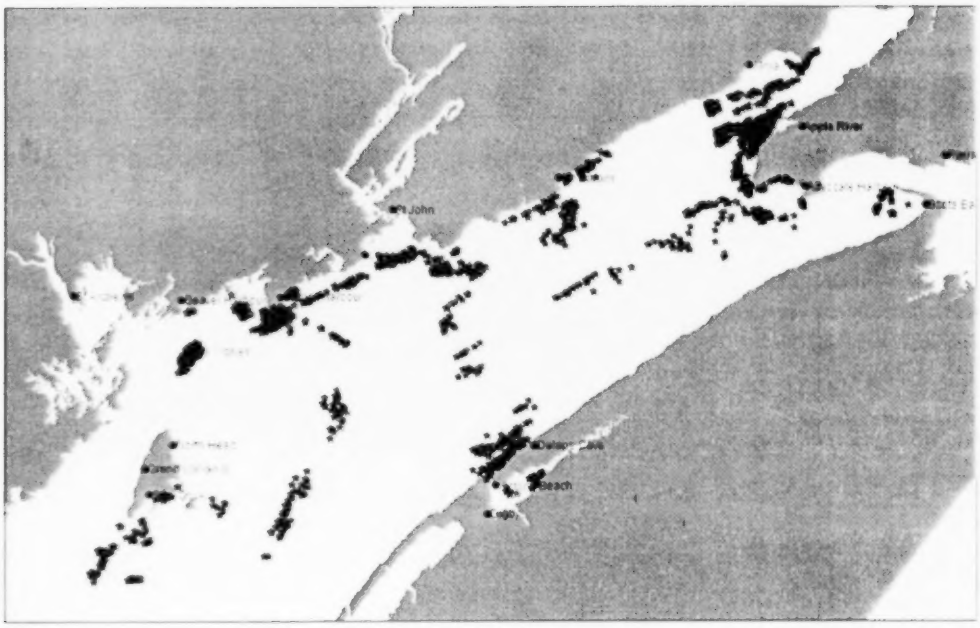

Figure 2.2.1. Locations of where traps were hauled during at-sea sampling between 2003 and 2006, including fall 2006. Each star may represent more than one trap haul.

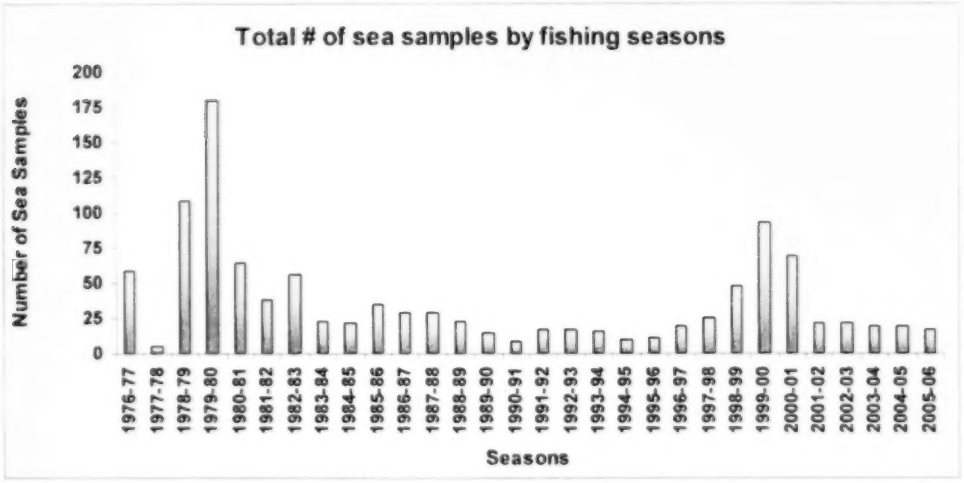


Figure 2.2.2. Number of sea sample per season for the Bay of Fundy.

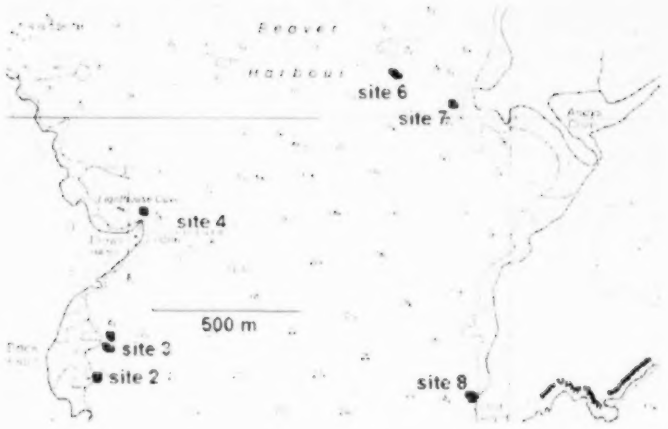


Figure 2.4.1a. Indicated are the dive locations, of the several specific sampling sites in Beaver Harbour where suction sampling have been done annually from 1991 to 2006.

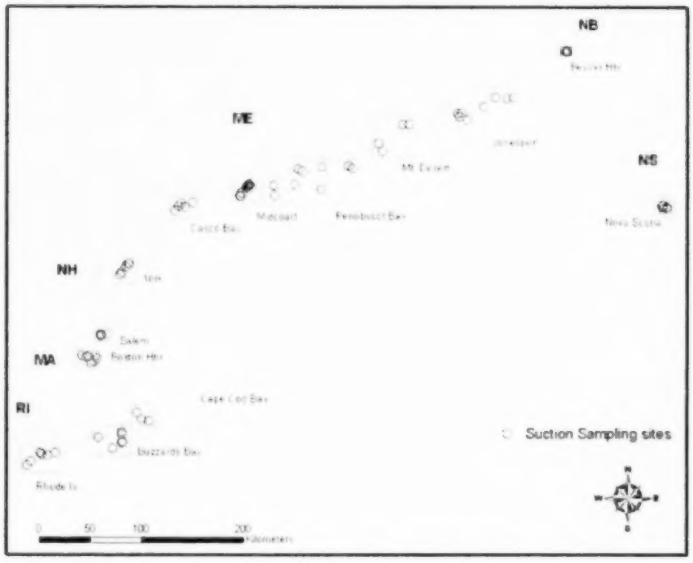


Figure 2.4.1b. Sampling sites of the New England lobster settlement index. Initiated at a few sites in Maine and Rhode Island in 1989-90, the survey now spans some 65 sites from RI to New Brunswick. Six new sites in Lobster Bay, Nova Scotia were sampled in 2005. Boxes surround sites used for regional averages. Surveys are conducted by divers using suction samplers in shallow rocky nurseries.

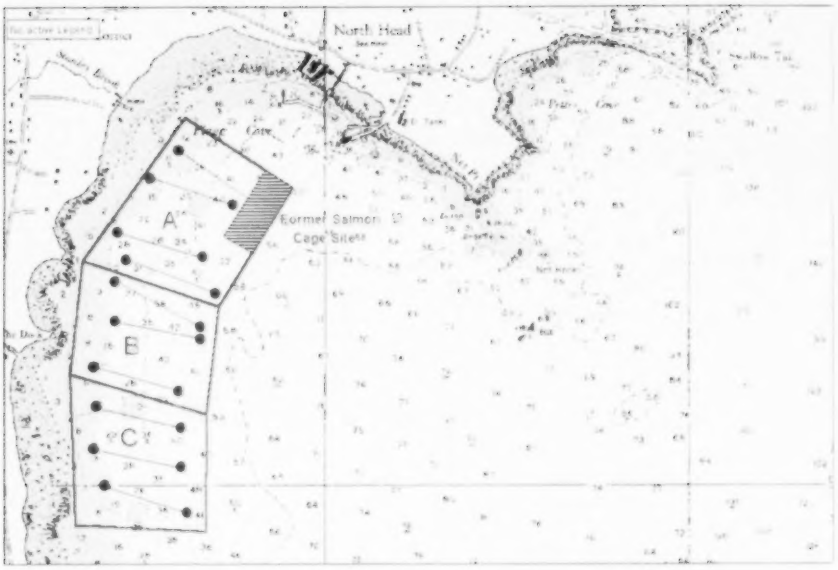


Figure 2.4.2. Map indicating general location of dive transects (300m x 2m) placed in three sampling areas of Flagg Cove, relative to the location of a salmon aquaculture site, active between 1989 and 1991. Only the combined lobsters samples from Area A & B are used in this analysis.

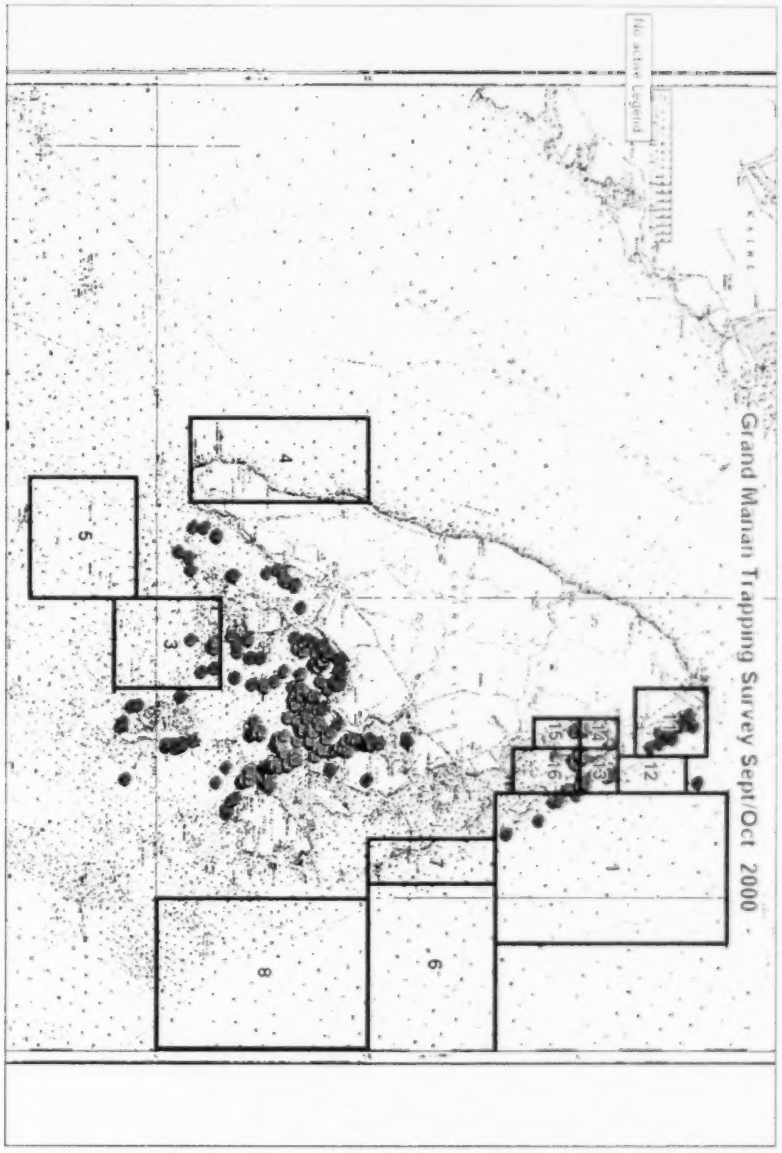


Figure 2.4.3a. Location of commercial traps during the 2000 (dots) out of season trapping surveys in northern Grand Manan (Top) and Southern Grand Manan (Bottom). The historical (1977, 1978, and 1982) trapping locations are located within the areas inside the boxes.

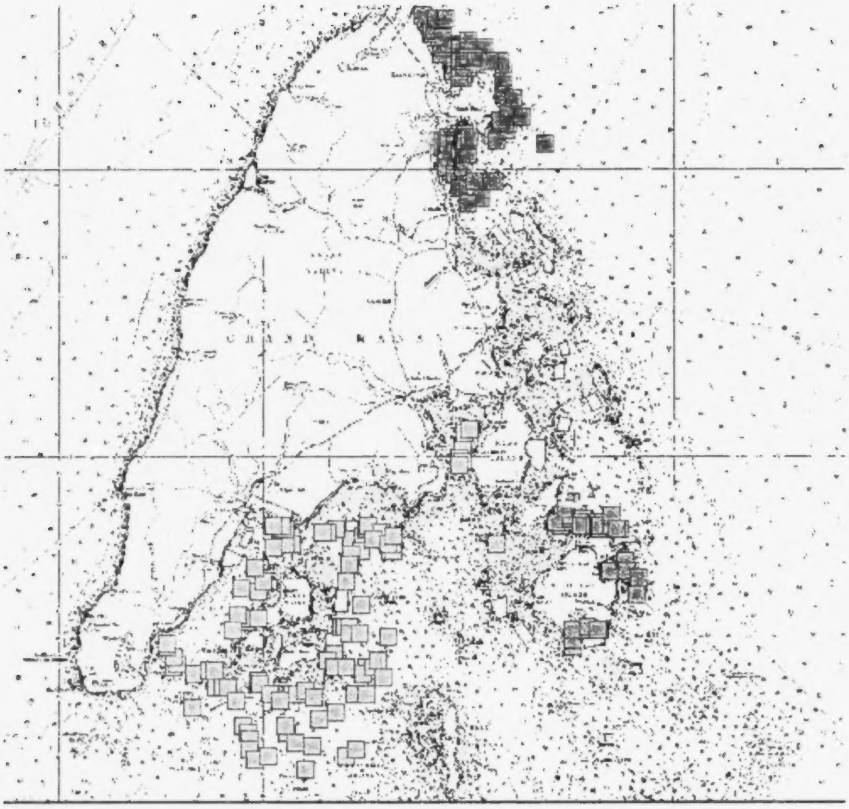

Figure 2.4.3b. Location of commercial traps during the 2001 out of season trapping surveys in Northern Grand Manan (Top) and Southern Grand Manan (Bottom).

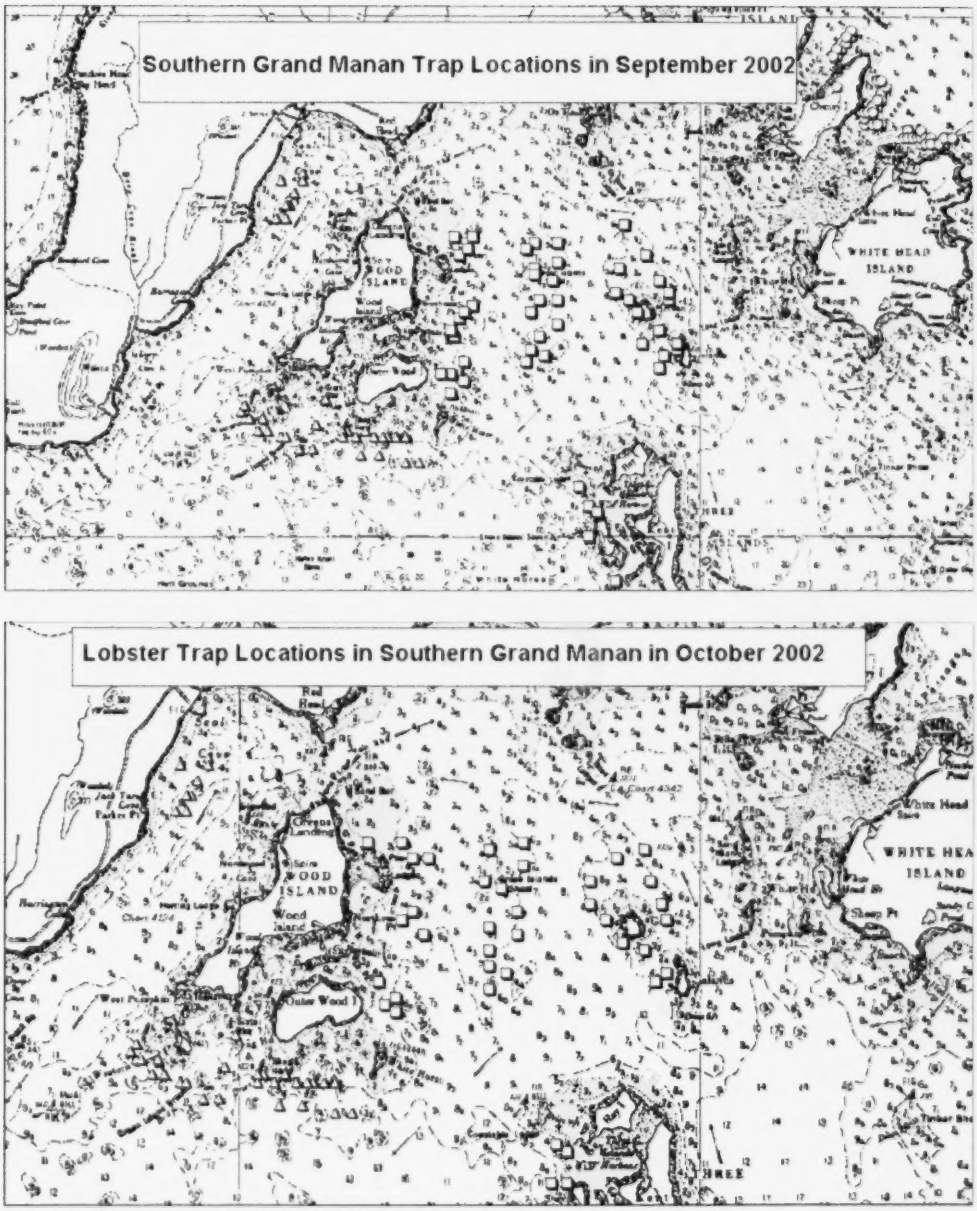
Southern Grand Manan Trap Locations in September 2002
WHITE HEAD ISLAND
Lobster Trap Locations in Southern Grand Manan in October 2002
WOOD ISLAND
WHITE HEA ISLAND

Figure 2.4.3c. Location of commercial traps during the 2002 out of season trapping surveys in Southern Grand Manan during September (Top) and October (Bottom).

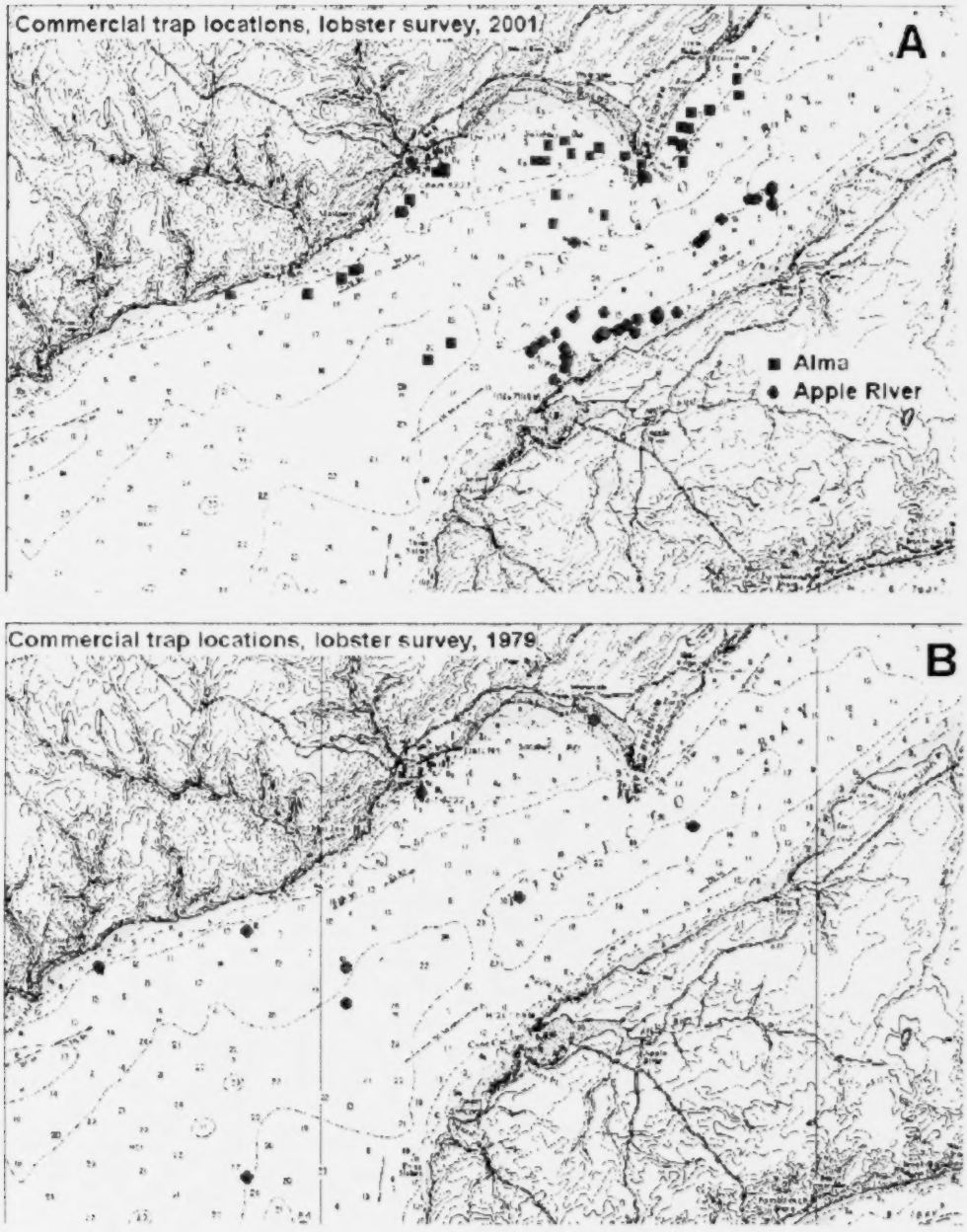


Figure 2.4.3d. Location of commercial traps during the 2001 out of season trapping surveys in the upper Bay of Fundy off Alma and Apple River (A) and the 1978 and 1979 (B) survey off Alma.

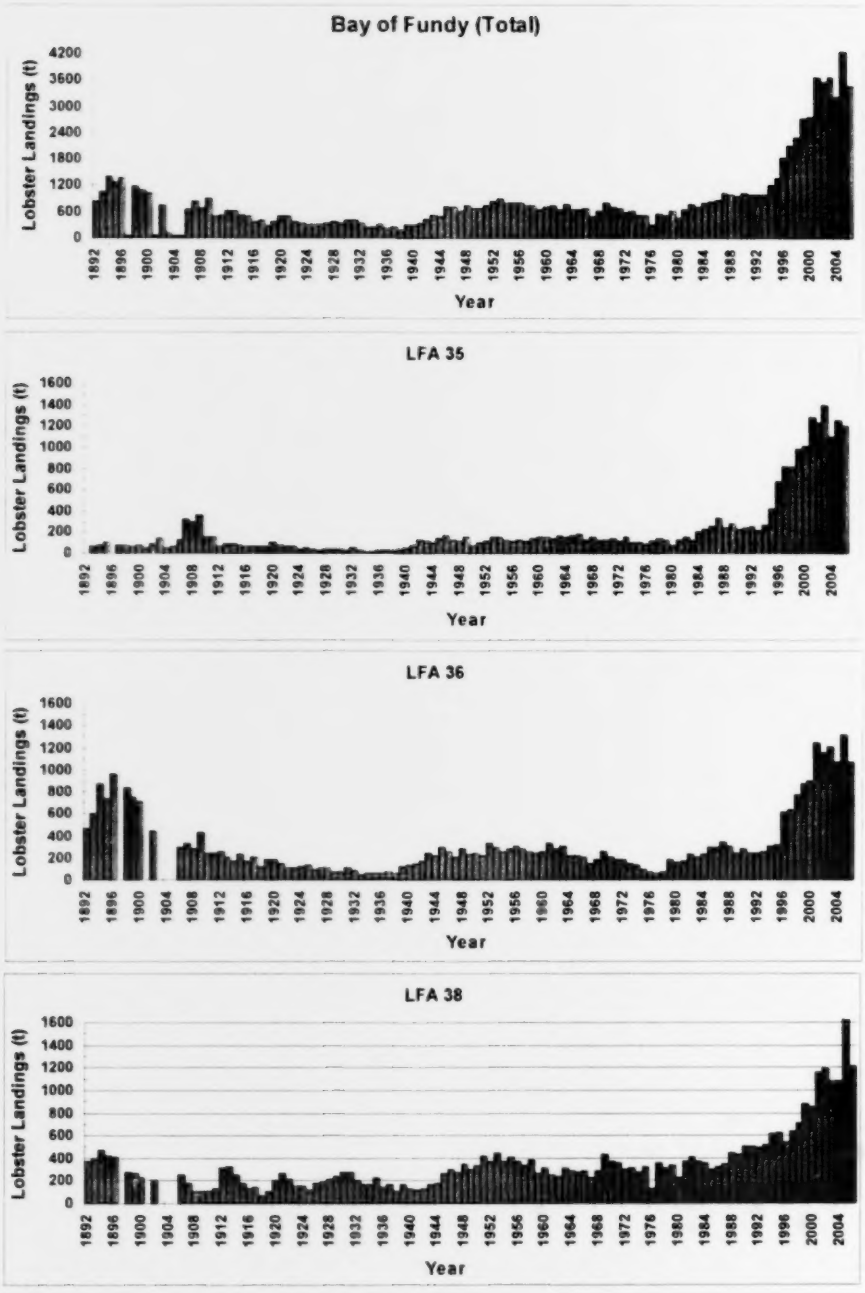


Figure 3.1.2a. Yearly lobster landings in metric tons (t), for the Bay of Fundy (top), and for individual LFA's (LFA 35, 36 and 38).

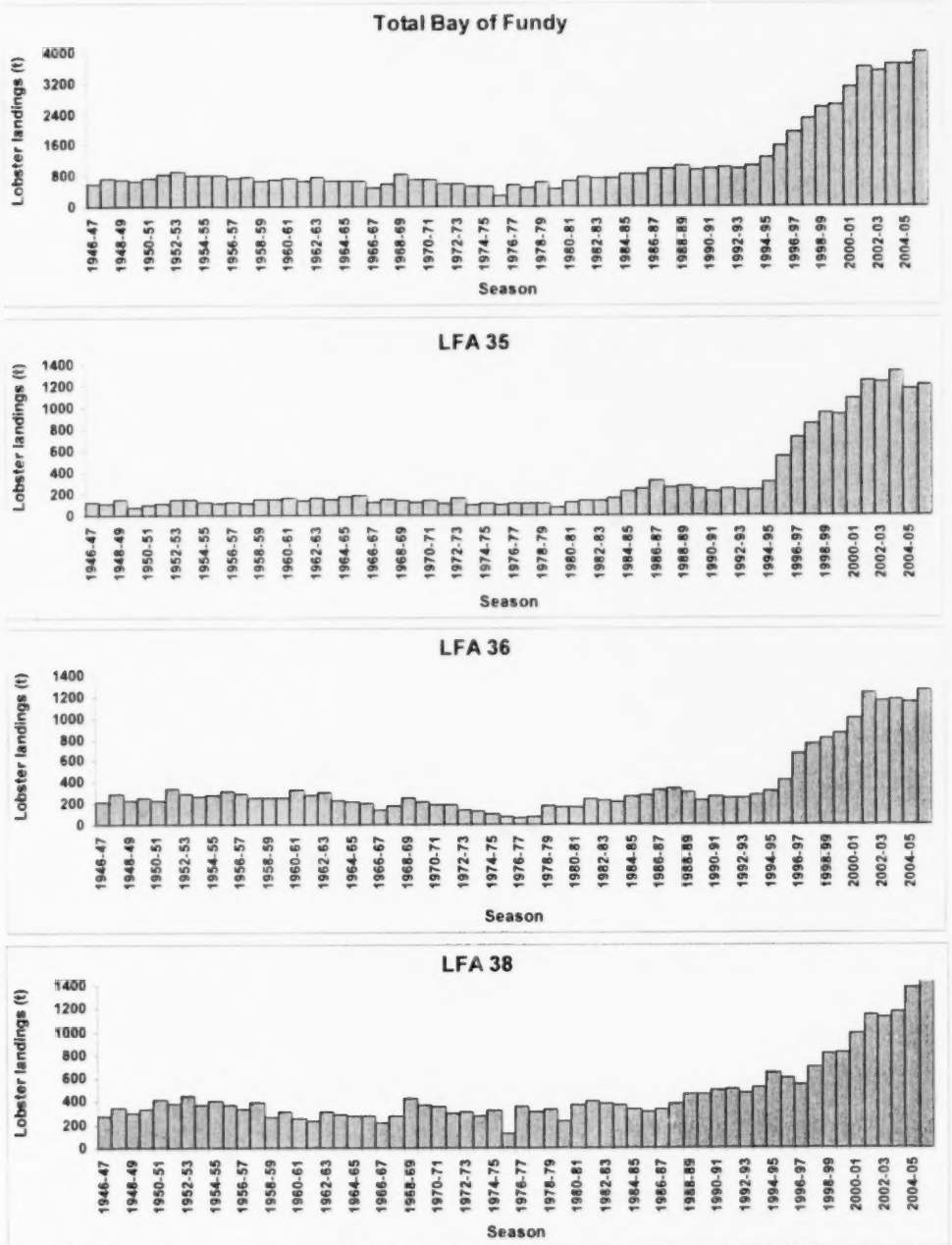


Figure 3.1.2b. Seasonal lobster landings in metric tons (t).for the Bay of Fundy (top) and for individual LFAs (LFA 35, 36 and 38)

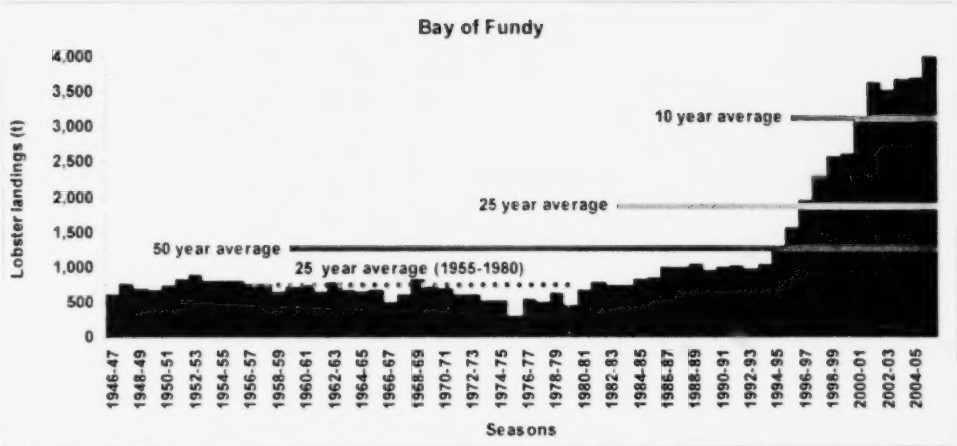


Figure 3.1.2c. Lobster landings in the Bay of Fundy showing historical means.

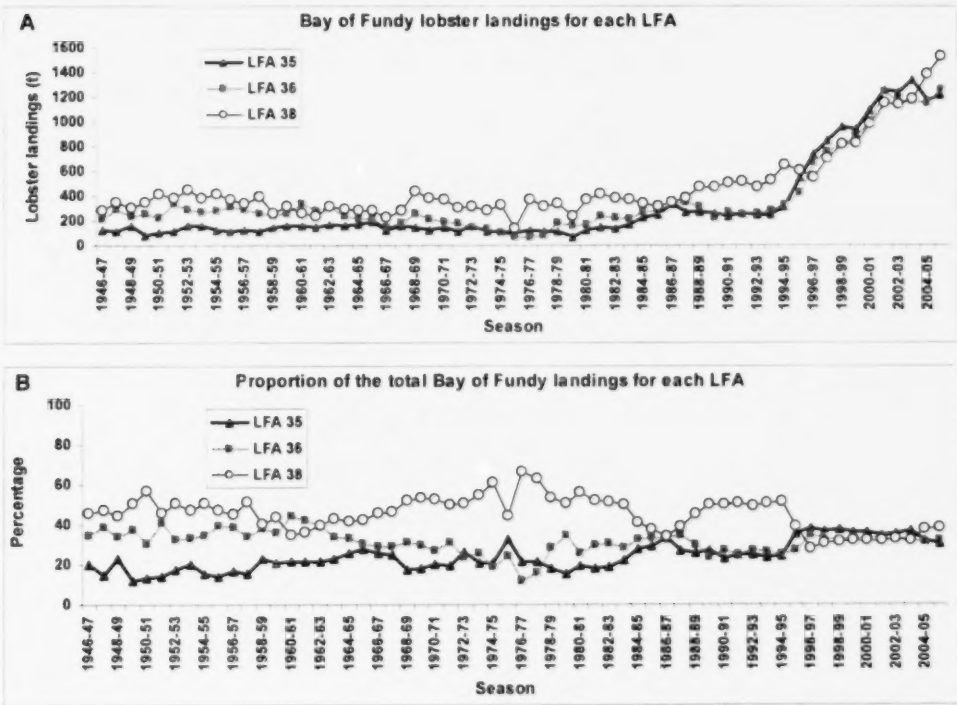


Figure 3.1.2d. Seasonal lobster landings (t) by LFA (A) and the proportion of the total Bay of Fundy lobster landings for individual LFA's (B).

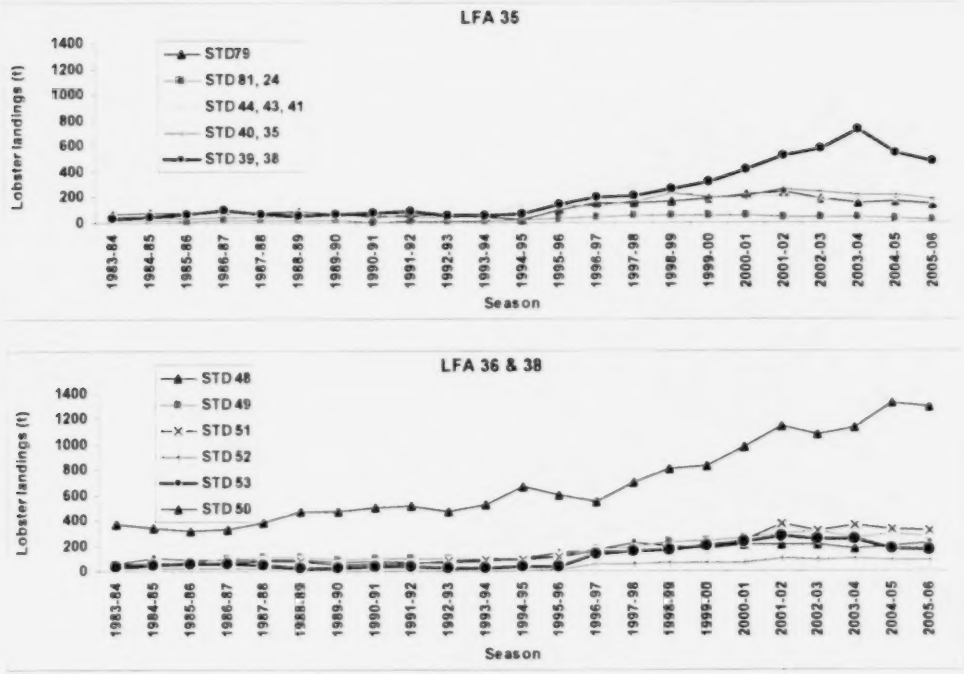


Figure 3.1.3. Lobster landings (t) by Statistical District for LFA 35 (above) and LFAs 36 & 38 (below).

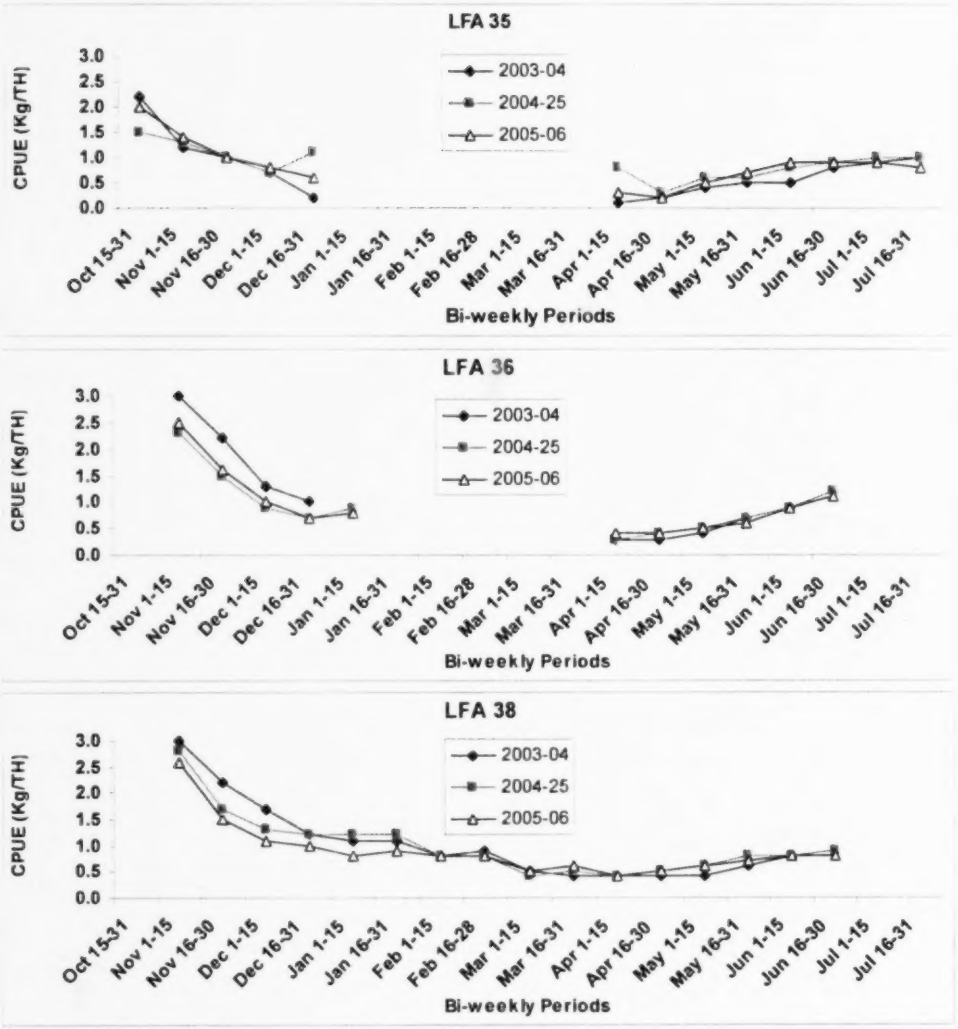


Figure 3.2. Lobster catch rates in kilograms per trap haul (Kg/th) by two week periods for LFA's 35, 36 and 38, during the last three fishing seasons (2003-04 to 2005-06).

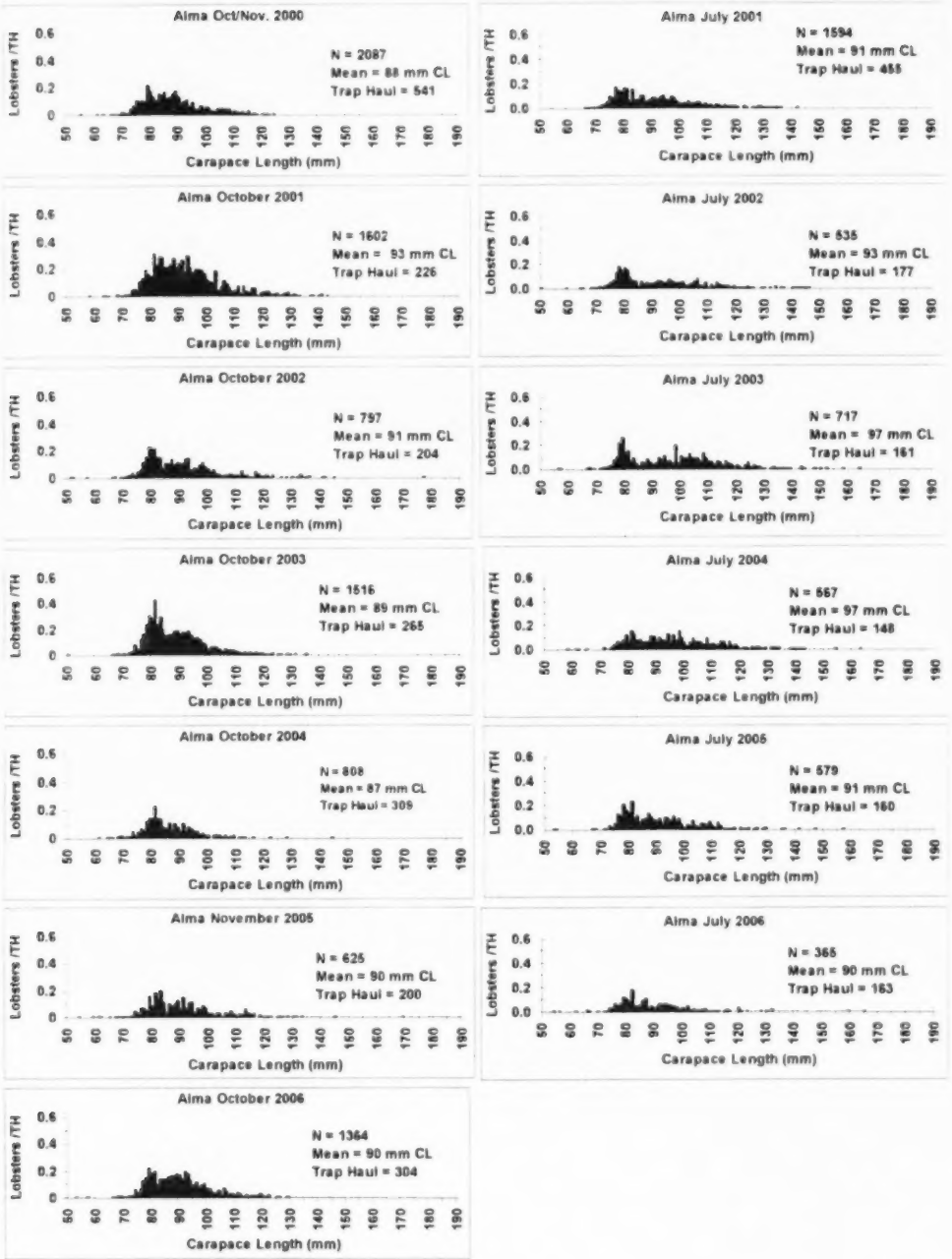


Figure 3.3a. At-sea sampling size frequencies for fishing seasons 2000/01 to 2005/06 for Alma (LFA 35).

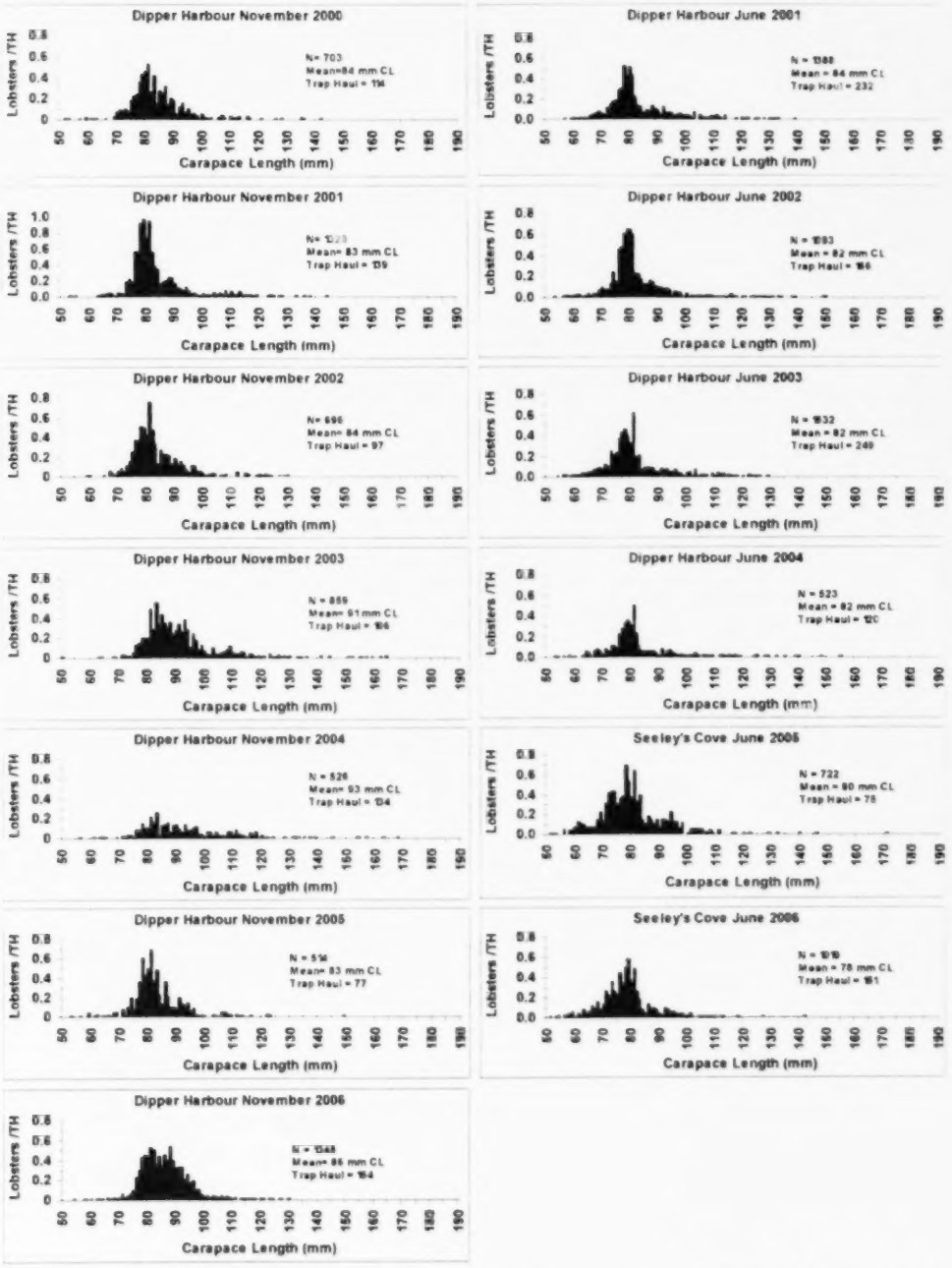


Figure 3.3b. At-sea sampling size frequencies for fishing seasons 2000/01 to 2005/06 for Dipper Harbour (LFA 36).

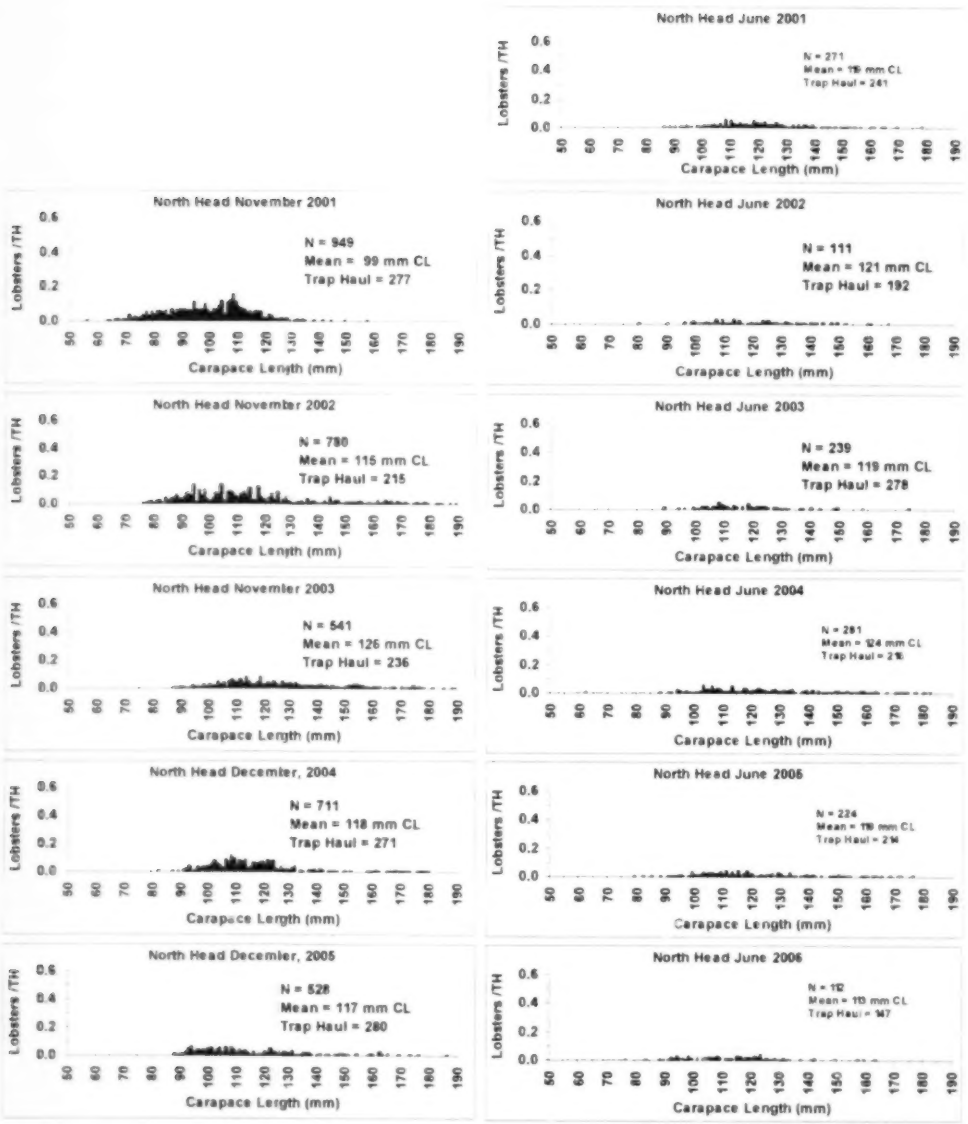


Figure 3.3c. At-sea sampling size frequencies for fishing seasons 2000/01 to 2005/06 for North Head (LFA 38).

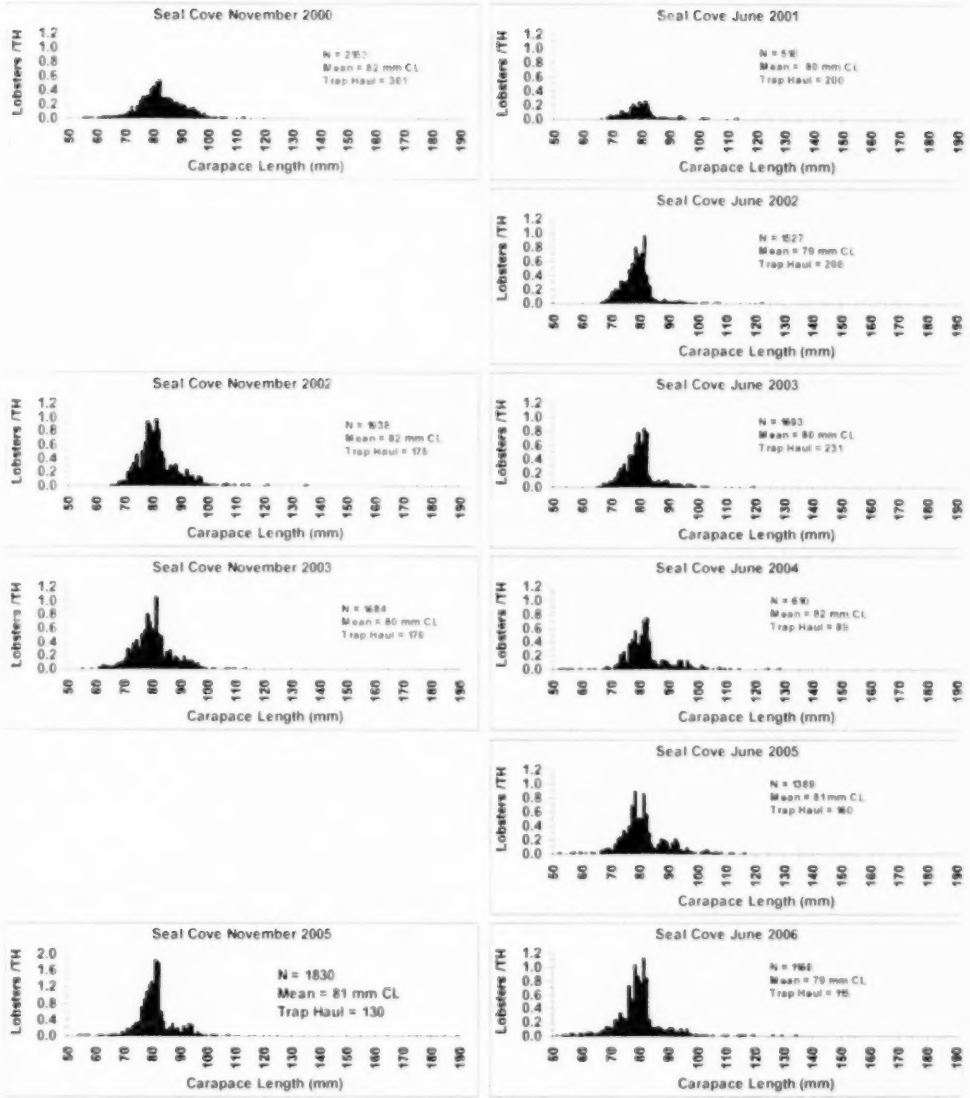


Figure 3.3d. At-sea sampling size frequencies for fishing seasons 2000/01 to 2005/06 for Seal Cove (LFA 38).

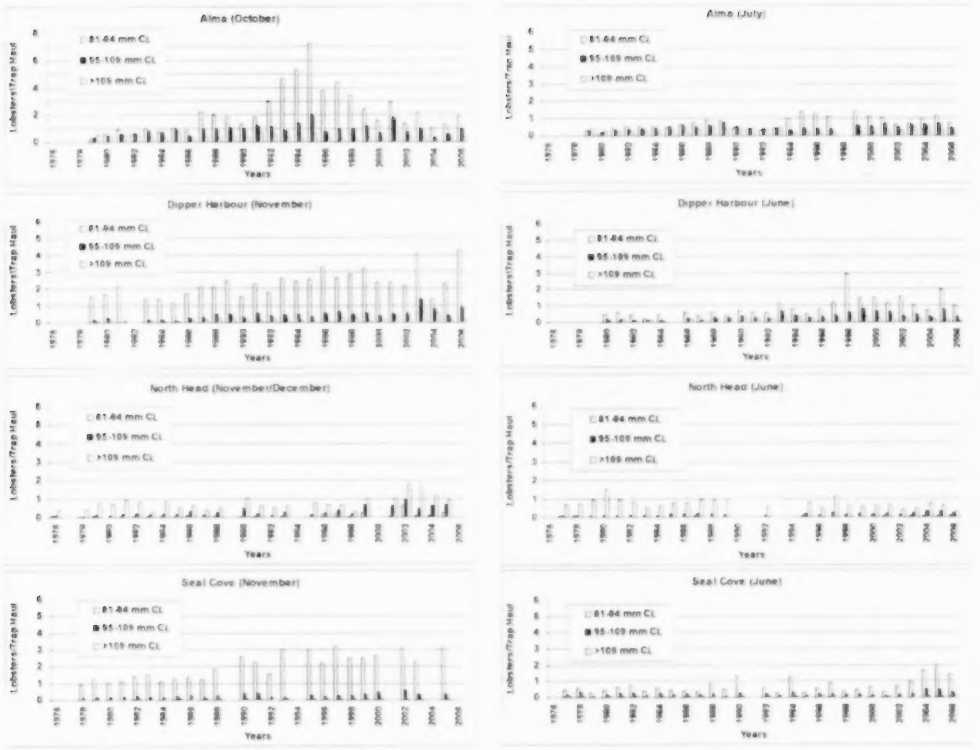


Figure 3.3e. Trends for three molt groups in numbers of lobsters per trap haul, observed from at-sea sampling, from four areas of the Bay of Fundy 1976-2006.

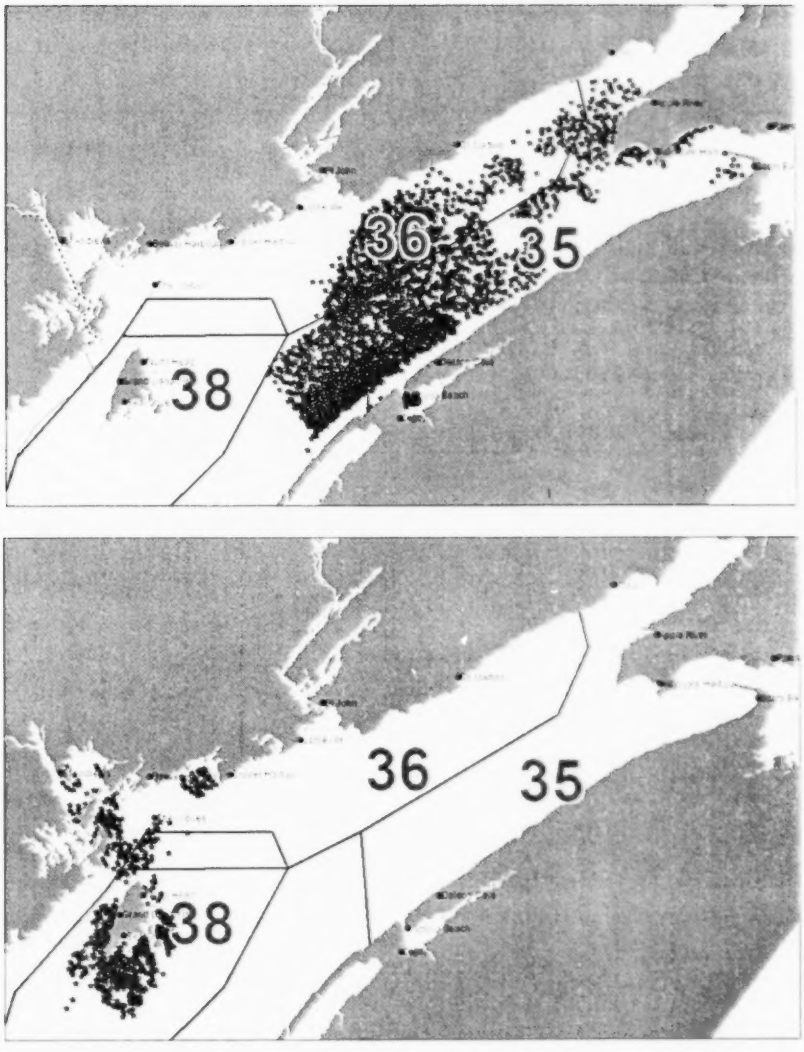


Figure 3.4a Scallop survey locations in the upper Bay of Fundy (Top) and in the lower Bay of Fundy (Bottom) between 1997 and 2006.

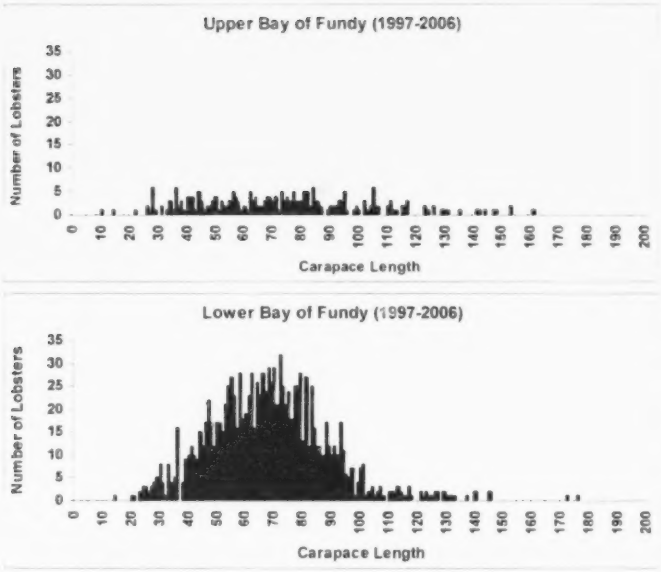


Figure 3.4b. Size frequency of lobsters captured in all scallop surveys between 1997 and 2006, in the upper Bay of Fundy (Top) and the lower Bay of Fundy (Bottom).

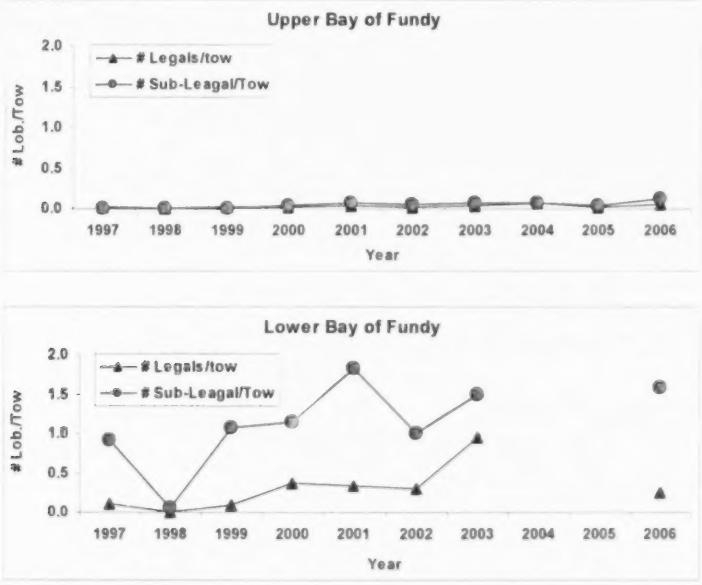


Figure 3.4c. Lobster catch rate in number of lobsters per tow (# Lob/tow) in scallop surveys for LFA 38 (Top) and LFA 35 & 36 (Bottom). The catch rate is shown in two sizes of lobsters: Sub-legal (< 83 mm CL) and legal lobsters (> 82 mm CL).

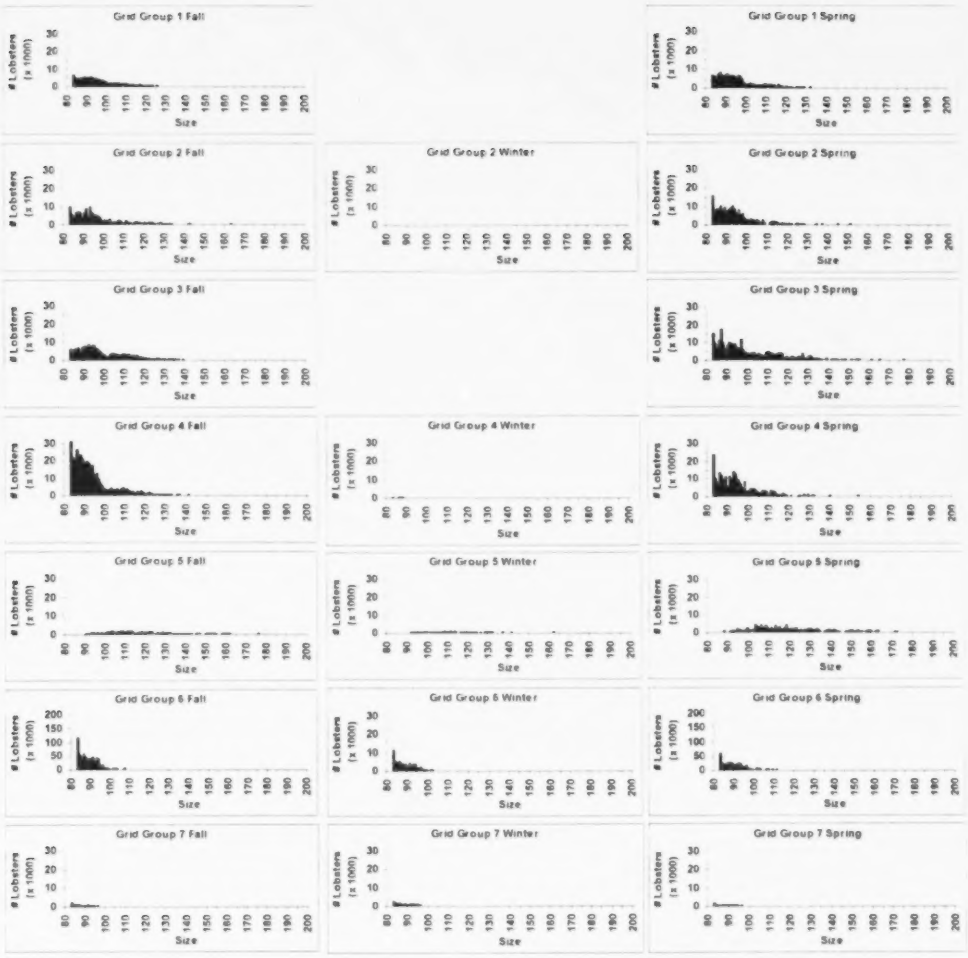


Figure 4.2a. Histograms showing the number of lobsters landed by Grid Groups and seasons (Fall, Winter, Spring) in the Bay of Fundy during the 2004-05 fishing season.

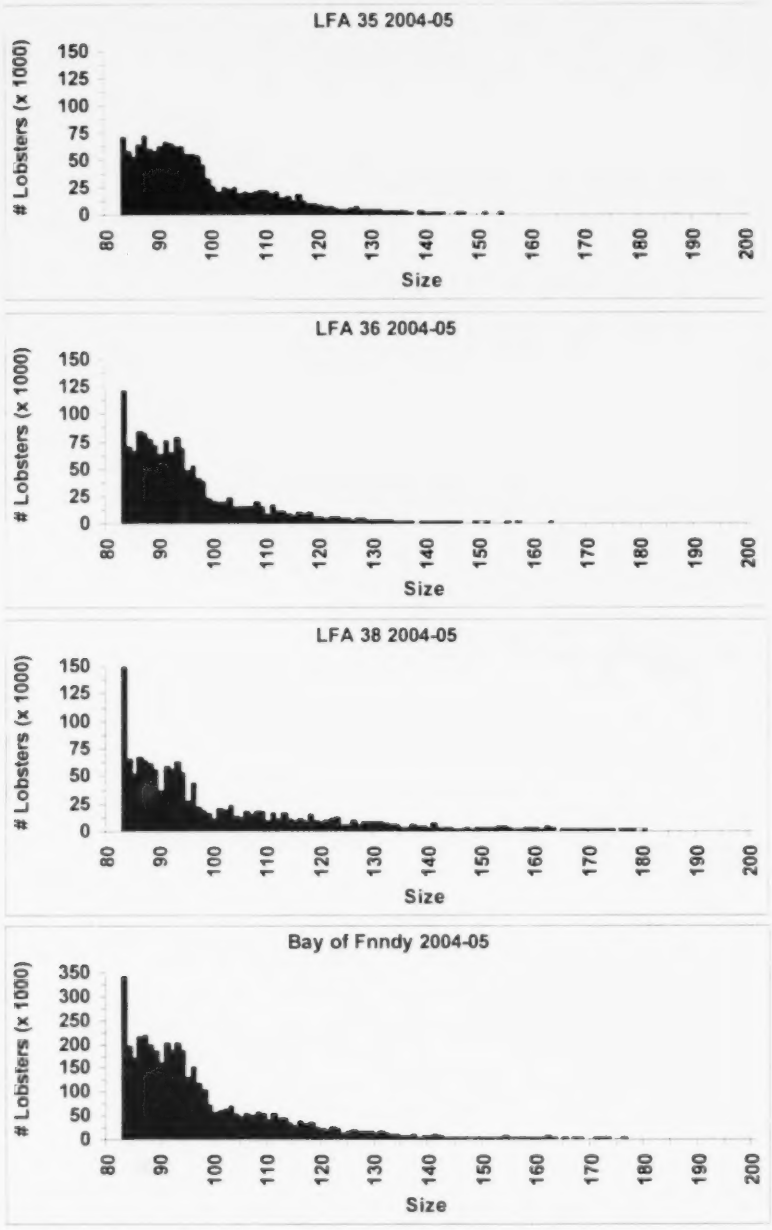


Figure 4.2b. Histograms showing the number of lobsters landed in each LFA and the Bay of Fundy as a whole during the 2004-05 fishing season.

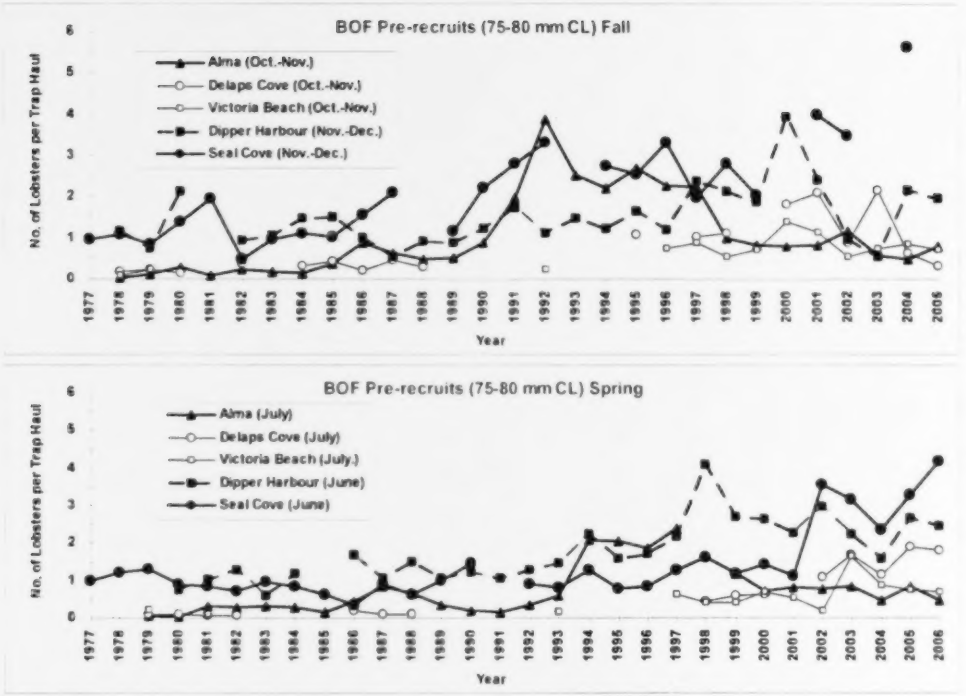


Figure 5.1. Catch rate in number of lobsters per trap haul of pre-recruits (75 to 80 or 77-82 mm CL) during fall (Top) and Spring (Bottom) off Alma, Delaps Cove, Victoria Beach, Dipper Harbour and Seal Cove from at-sea sampling between 1977 and 2006.

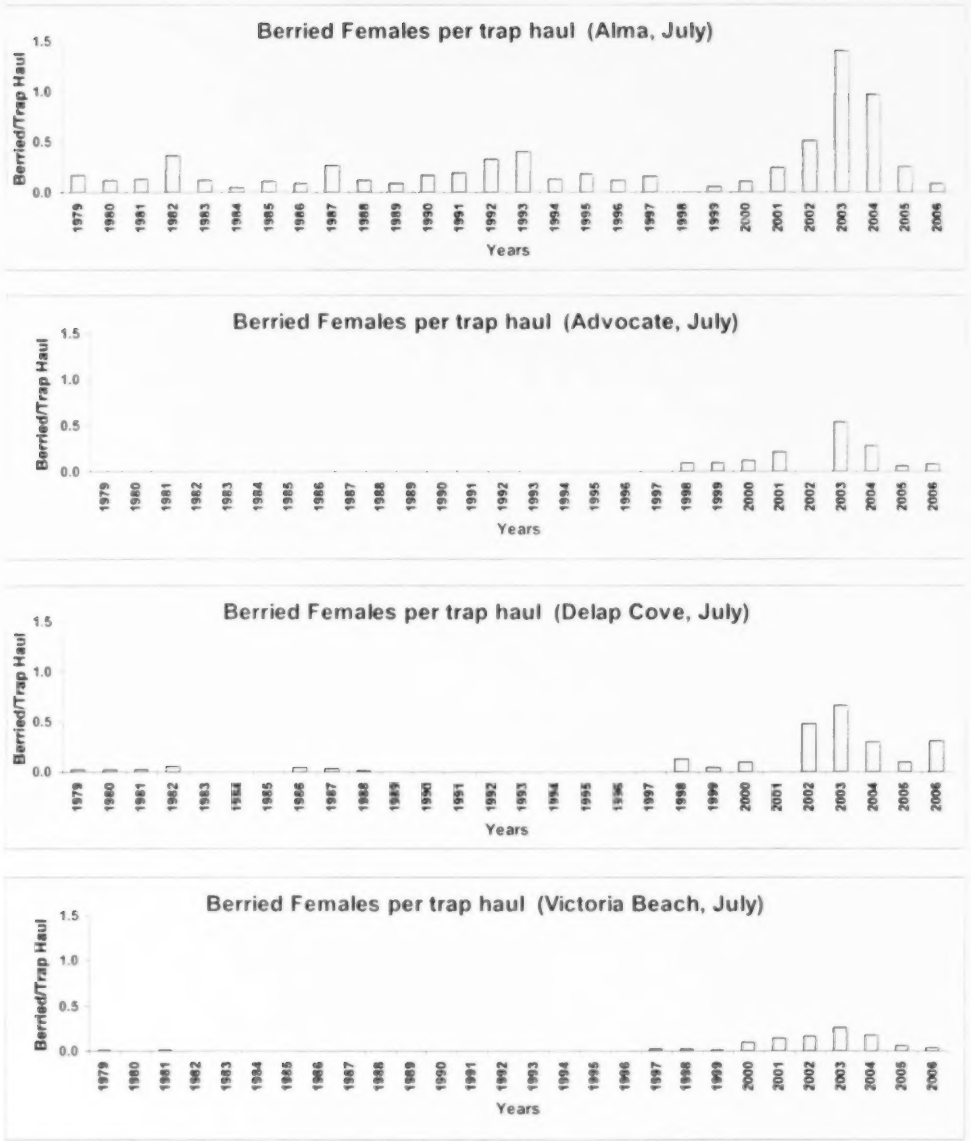


Figure 5.2. Catch rates in number of berried females per trap haul from at-sea sampling off Alma, Advocate Harbour, Delaps Cove and Victoria Beach, during the month of July from 1979 to 2006.

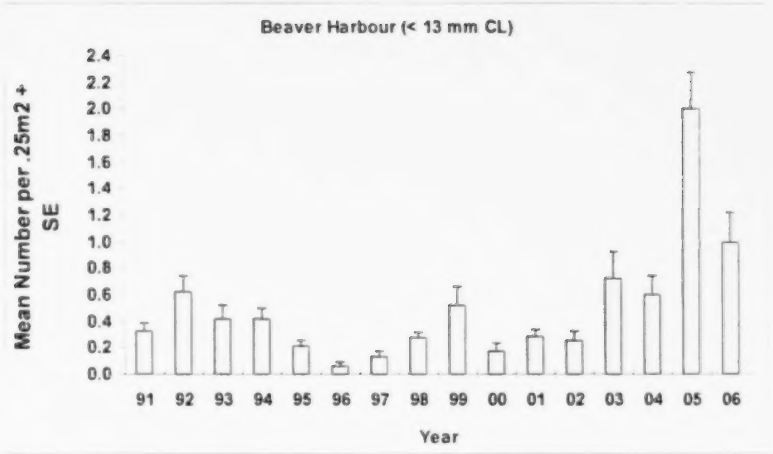


Figure 5.3.1a. Annual settlement density at Beaver Harbour (lobsters < 13 mm CL).

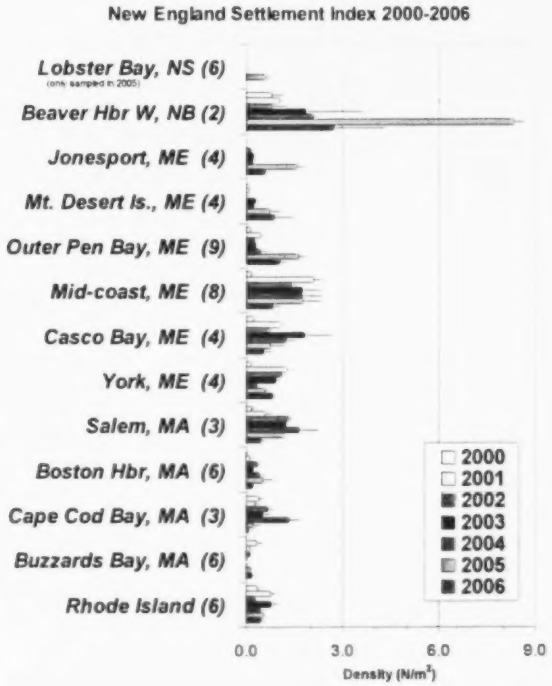


Figure 5.3.1b. Regional average lobster settlement throughout New England from 2000 to 2006. Number of sites averaged for a region in parentheses.

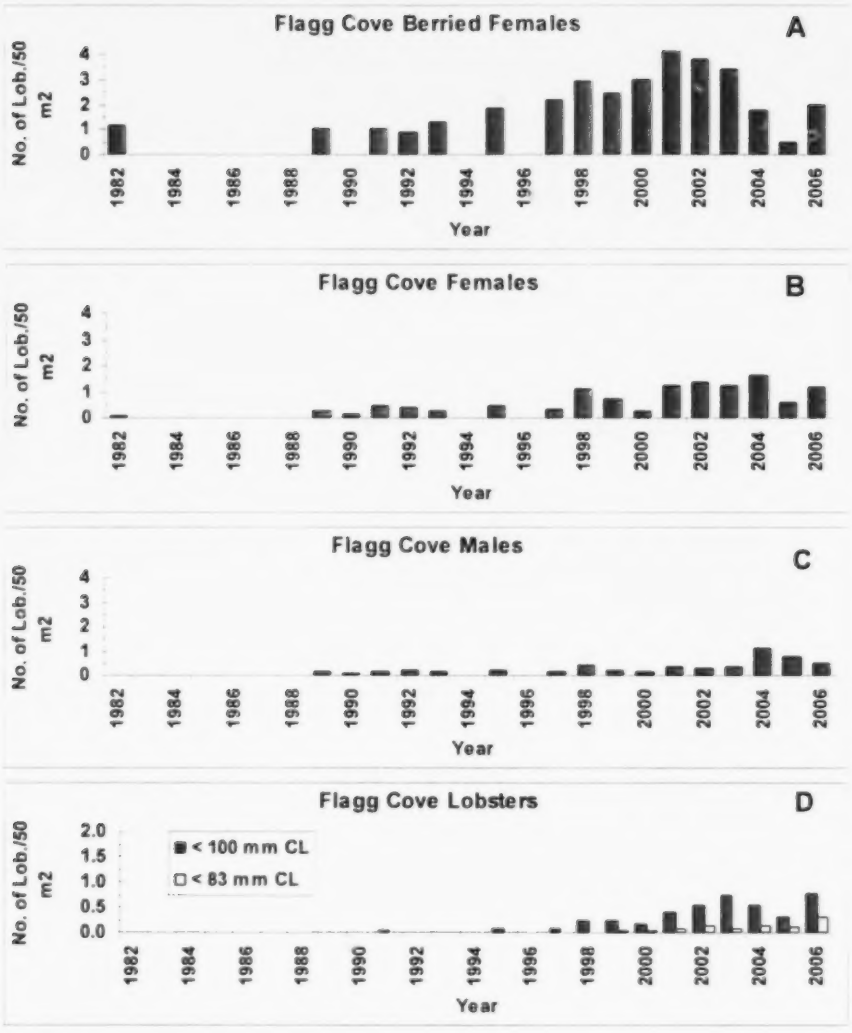


Figure 5.3.2. The graph presents the average density of lobsters in Area A and B combined, sampled yearly during the month of September since 1989 and in September 1982. The density is expressed by the minimum sampling unit (25 m transect section; $50m^2$). The average densities for berried females is showed in (A), females in (B), males in (C) and lobster less than 100 mm CL (D) and less than 83 mm CL in (D), sampled in Flagg Cove, Grand Manan between 1982 and 2006.

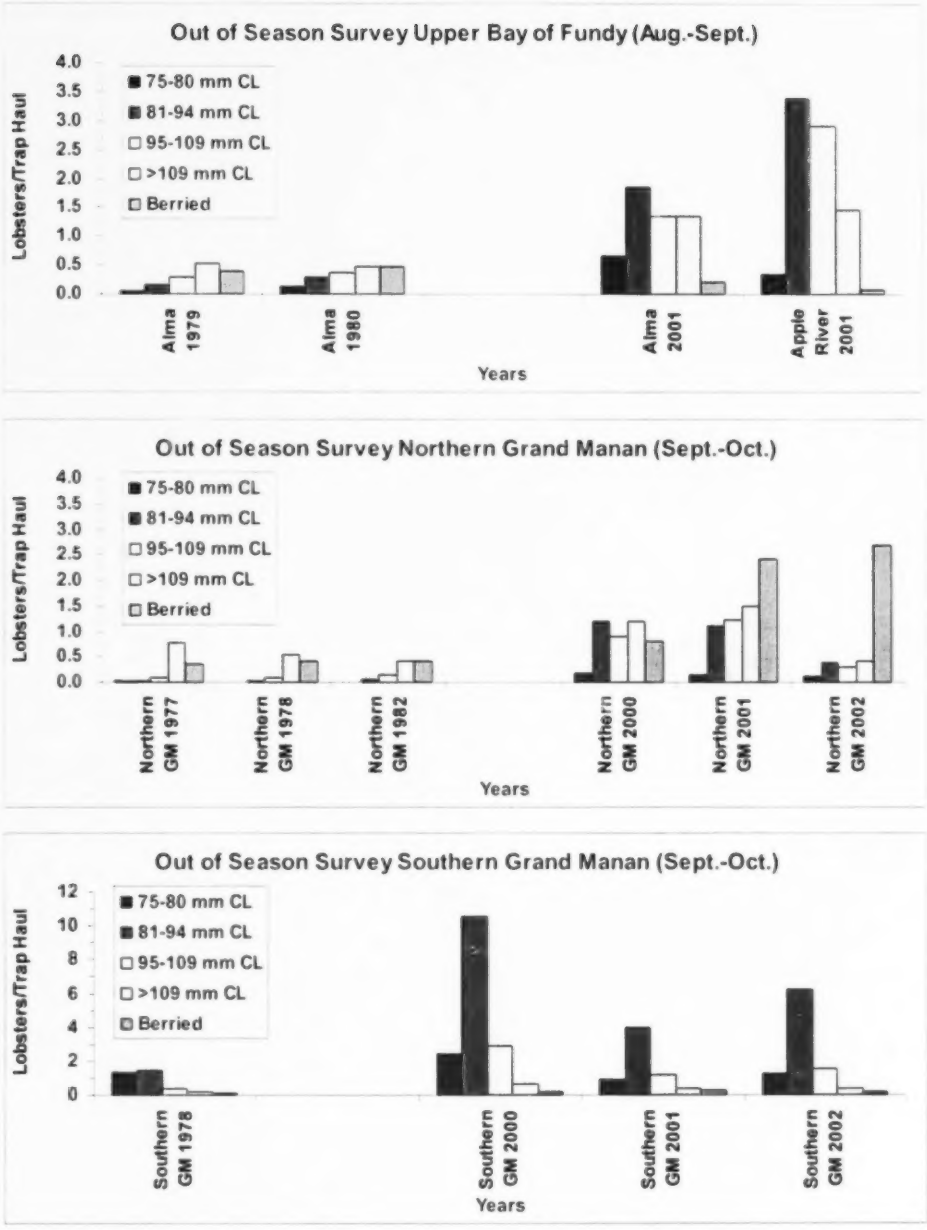


Figure 5.3.3. Comparison of the number of lobsters per trap haul by molt groups and berried females, between the 2000, 2001 and 2002 trapping surveys and the historical trapping surveys done during 1977, 1978, 1979, 1980 and 1982 for the Upper Bay of Fundy (Top), Northern Grand Manan (Middle) and Southern Grand Manan (Bottom).